STREETS AND ROADS DESIGN CHAPTER

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STREETS AND ROADS DESIGN CHAPTER

1.0 GENERAL

1.1 Definitions

a. In these Standards, the terms "roads and streets" identifies any public highway, thoroughfare, road, street, cul-de-sac, or service road. The term "highways" identifies traffic ways under the jurisdiction of the Maryland State Highway Administration.

b. Service Road: A local access road to provide a means of egress and ingress to a non-residential development for the purpose of limiting access directly onto a collector or arterial roadway. The minimum right-of-way and pavement width shall be 40 feet and 24 feet, respectively.

c. Local Road or Street: The local street comprises all facilities not in use of the higher order systems. It is intended to carry the least amount of traffic at the lowest speed and provide the safest and most desirable environment for a residential neighborhood, with the maximum number of homes fronting the street. The local street provides access to land adjacent to the collector network and serves travel over relatively short distances. The minimum right-of-way and pavement width shall be 50 feet and 30 feet, respectively.

d. Collector Road or Street: This is the highest order of street that could be classified as residential. This class of street is necessary to carry traffic from one neighborhood to another or from the neighborhood to streets connecting to other areas in the community. Direct access to homes is discouraged onto collector roads. The minimum right-of-way and pavement width shall be 60 feet and 34 feet, respectively.

e. Minor Arterial: This classification of roadway generally provides for movement of vehicles larger in number than collectors and local roads, with no direct access from homes allowed. This classification of roadway receives volumes of traffic from collectors and provides inter- and intra-county access throughout the municipality and county. The minimum right-of-way and pavement width shall be 80 feet and 40 feet, respectively.

f. Major Arterial: This is the highest order of street or road. This classification of roadway carries the highest volume of traffic through the municipalities and county and does not provide for direct access from homes or commercial development. The minimum right-of-way and pavement width shall be 100 feet and 48 feet, respectively.

g. (ADT) Average Daily Traffic: The total volume of traffic during a given time period (in whole days), greater than one day and less than one year, divided by the number of days in that time period.

h. Peak-Hour Traffic: The volume of traffic during the hour of day with the highest volume. For design purposes, this should represent the 30th highest hourly volume of the year, or 30 HV, and generally represents 15% - 25% of the ADT.

i. Design Speed: The maximum safe speed that can be maintained over a specified section of road or street when conditions are so favorable that the design features of the road govern.

j. Capacity: The maximum hourly rate of traffic at which persons or vehicles can reasonably be expected to traverse a point or uniform section of road during a given time period under prevailing roadway and traffic conditions.

k. Stopping Sight Distance: The length of roadway ahead visible to the driver. Stopping sight distance is the sum of two distances: the distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied; and the distance required to stop the vehicle from the instant the brake application begins. These are referred to as brake reaction distance and braking distance, respectively.

l. Passing Sight Distance: The length needed to safely complete normal passing maneuvers, generally determined for a single vehicle passing a single vehicle. The minimum passing sight distance for two-lane roads is determined as the sum of the four distances:

   1. Distance traversed during perception and reaction time during the initial acceleration to the point of encroachment on the left lane.

   2. Distance traveled while the passing vehicle occupies the left lane.

   3. Distance between the passing vehicle at the end of its maneuver and the opposing vehicle.

   4. Distance traversed by an opposing vehicle for two-thirds of the time the passing vehicle occupies the left lane, or 2/3 of "2" above.

m. AASHTO: American Association of State Highway and Transportation Officials.

n. Alley: A public right-of-way which affords only a secondary means of access to abutting properties.

o. Level of Service: The degree of traffic congestion as determined by methodology contained in the *Highway Capacity Manual*.

1.2 Responsibility for Design and Construction

a. City roads and streets in or related to new development are designed by Developers or their consulting engineers. City projects are designed by either the City or consulting engineers.

b. Construction of roads and streets in or related to new development is the responsibility of the Developer. These projects are constructed by either a contractor hired by the Developer or the Developer's own forces with rights-of-way deeded to the City.

c. The Developer shall provide the City with a minimum one-year warranty from the date of acceptance of the improvements by the City for all work constructed by the Developer. The City shall withhold all of the contingency portion of the surety associated with road work (i.e. paving, curb and gutter, sidewalk) until the warranty period expires.

d. The City will not accept the road improvements until all construction is complete, final paving is installed, build-out is complete, and there is no longer a need to use the completed road for construction traffic. No construction traffic will be permitted on streets that have been accepted by the City. If phased, only that phase must be complete. A temporary turnaround may be requested at end of each phase but not accepted by the City.

Any street, cul-de-sac, alley or public right-of-way must meet the requirements of the Brunswick Subdivision regulations, Design Manual and other applicable standards and specifications to be taken into the Municipal Street System. The City of Brunswick is not obligated to upgrade any street, cul-de-sac, alley or public right-of-way to these standards unless it is deemed advisable to facilitate traffic flow or to address a public safety matter.

e. All public and private streets and alleys shall be inspected by the City of Brunswick, in accordance with City Inspection Procedures, at the expense of the developer.

1.3 Authorization Permits

a. Where intersections occur with roadways under the jurisdiction of the Maryland State Highway Administration, Frederick county, or other political districts, a permit from the office involved authorizing the proposed construction must be filed with the City before plans will be approved.

b. Where permits are required from other agencies, such as the Natural Resources Conservation Service, Maryland Department of the Environment or Army Corps of Engineers, a signed permit from those agencies having authorization over the project must be filed with the City before plans will be approved.

1.4 Planning Guidelines

The designation or classification of the road, street or alley shall be designed as stipulated in the City's Comprehensive Plan or as dictated by the City. The design standards of roads and streets, and the Transit-Oriented Design Guidelines (see Appendix B of this section) as shown herein shall be used. In the event a development is submitted for review to the Planning Commission as a Planned Unit Development (PUD), the Planning Commission, at its discretion, may alter the design standards herein as they deem appropriate. In the event a conflict exists between the requirements, the more stringent applies.

1.5 Existing Streets

Each street abutting or affecting the design of a subdivision or land development which is not already classified in the comprehensive plan shall be classified to its function, design and use by the City at the request of the applicant or during plan review. The classification of existing streets shall include the hierarchy noted above or classification of higher order, as determined by the City.

2.0 DESIGN

2.1 Preliminary Considerations

The design of roads and streets includes general layout, curb and gutters, signage, sidewalk, alignment, grades, grading, paving widths, paving material, and drainage facilities. Sufficient rights-of-way should be set aside in the early stages of layout to provide for future increases in pavement widths and roadside improvements when practical. When determining alignments and grades of roads and streets, the designer must consider the requirements for utilities, including adequate storm drainage, and he must take into account any unusual aspects of the design, such as railroad crossings, floodplain crossings, intersection improvements with State or County roads and traffic signals.

2.2 Layout of Intersections

a. Centerlines of traffic ways shall continue through intersections without offsets and shall intersect as nearly as possible at right angles. Where various conditions make a right angle intersection impracticable, the minimum deflection angle between the centerline of a street and the centerline of any other street shall be 60 degrees or 70 degrees when intersecting State Roads.

b. There must be an unobstructed sight distance along all approaches at an intersection across their included corners for a distance sufficient to allow operators of vehicles to accelerate, slow down, or stop. The design is commonly called the intersection sight triangle. All intersections should be designed with angle of intersection at 90 degrees. AASHTO's discussion of intersection sight distance shall predominate, but is too long to be included here. Since local residential access streets will inherently be low speed roads, then one can plan on only having to satisfy AASHTO's requirement for 30 mph situations. Stopped intersections of local roads shall have a minimum sight distance of 150 feet. AASHTO's guidelines, as discussed in A Policy on Geometric Design of Highways and Street, latest edition, Chapters 5, 6, and 7, will govern except as modified in this design manual.

c. At the intersection of two (2) closed section streets, consideration must be given to the radius of the return. A minimum curb radius of 20 feet should be provided with 25 feet minimum at the intersection with State or County highways.

d. At an intersection of an alley and a street, the standard radius of the return shall be 10 feet to face of curb. Where the distance on the street between the face of the curb and property line is less than 10 feet, that distance shall become the return radius.

e. Where alleys intersect at 90 degree angles, the fillet triangle formed shall have legs of 15 feet. At intersections other than 90 degrees, the fillet triangles shall be subject to approval by the City.

f. The cut-back of property lines at intersections shall be governed by the following criteria:

    1. At an intersection of roadways (other than alleys), the cut-back of the property line normally shall be a chord connecting the points on the property lines directly opposite the Point of Curvature (P.C.) and Point of Tangency (P.T.) of the curb return or edge of pavement return. In any case, the minimum distance from the property line Point of Intersection (P.I.) at an intersection and the property line chord points shall be a minimum of 10 feet.

    2. At an intersection of an alley and a street, the property line shall not be cut-back.

    3. At an intersection of alleys, the property line shall conform with the pavement fillet.

g. A clear zone should be established that is free of all opaque obstructions greater than 3.0 feet high above the curb elevation. Such objects typically include:

buildings, cut slopes, hedges, trees, bushes, or tall crops. The triangular dimensions of the zone allow for the desired sight lines. This triangle shall have a minimum of 35 feet dimension on the edge of the pavement on both legs. This distance may be increased by the City if deemed appropriate for safety reasons. This design requires elimination of parking within the sight triangle. Street signs, fire hydrants, and utility poles typically can be located within a sight triangle, as long as they are not clustered and do not contribute to sight limitation.

h. Intersections shall be no less than 250 feet apart between roadway centerlines. (Local streets only.)

i. Refer to Table 2 in the Appendix for separation guidelines.

j. In certain situations, the design and construction of turning lanes or acceleration/deceleration lanes at intersections may be required to facilitate the movement of traffic through an intersection and improve traffic capacity and level of service. The Planning Commission reserves the right to require additional lanes of roadway for this purpose and to require additional rights-of-way to accommodate the additional lanes. Intersections will be reviewed on a case-by-case basis, and a final determination made by the Planning Commission as to the necessity for and the geometric requirements for additional turning lanes.

k. Intersections of more than two (2) streets at an intersection shall be prohibited.

2.3 Horizontal Curves

a. Where road and street centerlines change direction by more than one degree (1°), they shall be connected by a horizontal curve with a radius to insure a minimum horizontal sight distance, as shown in Table 1. Minimum radii of horizontal curves shall be limited as directed by the Table's minimum radius. The minimum radius of a horizontal curve shall be 150 feet.

b. Property lines which change direction through angles less than one degree (1°) need not have a horizontal curve introduced at the break, unless otherwise directed by the City.

c. Horizontal curve data shall be computed by the arc definition of a circular curve. A tangent of at least 100 feet shall be used between reverse curves. Horizontal alignments using compound curves shall be avoided.

2.4 Superelevation

Horizontal curves of road and streets in subdivisions, commercial and industrial areas, regardless of classification, shall not be superelevated.

2.5 Cul-de-Sacs; Tee Turn-Arounds; Driveways

2.5.1 Cul-de-Sacs

a. Generally, all residential parcels should be accessible from two directions. This usually reduces total vehicle miles of travel and improves emergency vehicle access. However, the most efficient subdivision of certain tracts (considering shape and terrain) may work best by locating limited numbers of lots along dead-end streets.

b. An 800-foot length shall be the maximum for cul-de-sacs unless otherwise approved by the Planning Commission. The minimum right-of-way radius for a traditional circular cul-de-sac is 50 feet. No eyebrow cul-de-sacs shall be permitted. The minimum length of a cul-de-sac shall be 350 feet from the centerline of the intersecting street to cul-de-sac curb. The minimum outside pavement/curb radius is 40 feet. Larger cul-de-sacs will be required in subdivisions with very large lots with sufficient lot width to allow curb parking around the cul-de-sac. The curb parking creates the need for larger pavement/curb radii to accommodate the parking, while providing sufficient turning radius for large trucks and fire apparatus. Oversized cul-de-sacs will also be required for school bus access, as determined necessary by staff at the preliminary plan stage. The minimum diameter of the right-of-way for over-sized cul-de-sacs, when required by the City, shall be 150 feet.

c. When outside curb (pavement) radii of 40 feet or greater are used, they create large expanses of pavement which may be unsightly. The use of center islands may be considered to reduce this paved area, if care is given to keeping adequate maneuver space around the island. A minimum pavement driving width of 20 feet is required around the island. The use and design of islands will be at the discretion of the Planning Commission. All islands, when approved by the City, will be rolled curbed.

d. In addition to the traditional circular cul-de-sac, an offset cul-de-sac may be provided. Generally, offset cul-de-sacs are used to overcome environment, topographic and property constraints.

e. At the connector between the cul-de-sac right-of-way, a transition radius is required. This radius should be at least 50 feet, to avoid an unsightly sidewalk layout and to provide smooth turning movements into and out of the cul-de-sac. Also, a more constant curb to right-of-way line dimension is achieved.

2.5.2 Tee Turn-Arounds

Tee Turn-Arounds will <u>not</u> be permitted as temporary or permanent facilities.

2.5.3 Driveways

Layout of driveway entrances shall conform with the applicable Typical Driveway Entrance Detail, shown in the Appendix.

2.6 Design Speed

Designation of a design speed is suspended here because other design elements serve to "limit" speeds in residential areas. Wherever possible in the other sections, an effort to design for 30 mph or less has been considered. Lower design speeds must be considered as progressively more difficult terrain is encountered.

The Developer or his Engineer shall submit with each project a proposed mechanism or method(s) for reducing traffic speed on the roadways being designed, particularly in residential areas. The mechanism or method(s) to achieve the desired result of reducing traffic speeds may consist of one or more different approaches.

2.7 Minimum Centerline Radius of Curves

The minimum centerline values for design of streets and roads are provided in Table 1. These values relate to mid-block horizontal centerline curves and <u>not</u> to intersection radii.

2.8 Minimum Tangent Between Reverse Curves

A minimum tangent of 100 feet at curves and intersections is needed between reverse curves to facilitate steering and control. Refer to Table 1 for minimum lengths for various roadway classifications.

2.9 On-Street Parking

a. Off-street parking requirements are addressed in the zoning and subdivision regulations. However, the adequacy of street widths is tied to available off-street parking and the need to provide on-street parking capability when off-street parking is not sufficient. The pavement widths provided in Table 1, and as shown in the Standard Details in the Appendix of this manual, provide the opportunity for on-street parking.

b. Studies have shown curb parking to be a primary factor in accidents on all types of streets. The number of children killed and injured each year as a result of entering the street from behind parked cars is particularly tragic. For these reasons, every development must meet off-street parking requirements so as to minimize curb parking.

c. Angle parking along the curbs of local streets should not be allowed. When traffic lanes are used for parking and parking maneuvers, the accident potential is much higher than with parallel parking. Therefore, all such bays and lots allowing any parking other than parallel, should be physically separated from the roadway and confined by barrier curbing beyond the street and the sidewalks.

2.10 Driveway Aprons

a. Because they are deceptively simple in appearance, driveway aprons often do not receive the design consideration that they merit. Common deficiencies include:

1. Inadequate radii at intersection with street;

2. Excessive grades and grade changes (breakover angles);

3. Inadequate width and depth of paving;

4. Inadequate sight-distance due to landscaping;

5. Poor drainage characteristics.

b. The typical residential driveway apron should be designed for passenger car operation only. The driveway radius or flare should be designed with consideration given to both the driveway and road width. Refer to the Standard Details in the Appendix of this chapter for a typical driveway apron design.

2.11 Minimum Tangent Length Approaching Intersection

It is desirable to provide a tangent section of roadway approaching intersections, when the street leg has minimum or near-minimum radius curve. However, curving collector streets need not have tangents approaching intersections with local streets, if the collector radius is 1,000 feet or greater.

2.12 Drainage Structures

a. Inlets or catch basins should not be located within the corner radius or within 6 feet of either end. Clearance is needed to keep the area relatively dry and to allow space for street lights, name signs, utility poles, etc. Grate design should provide for safety of bicycle traffic.

b. Special considerations should be given to the middle of the curb return at the upper end of the intersection of two streets in a downhill condition. A small area of ponding in the gutter can be created due to the gutter slope. Detailed spot elevations must be provided to show that all drainage will flow to the appropriate storm drain inlet.

2.13 Traffic Control

All signs, including stop signs and street identification signs, will be placed by the Developer at the expense of the Developer, according to the Manual of Uniform Traffic Control Design (MUTCD). All intersections of City roads and streets with other private or public streets, with the exception of State and County roads, are under the jurisdiction of the City of Brunswick. Intersections at State facilities are under Maryland State Highway Administration jurisdiction. On City roads and streets, the curbs shall be painted to identify or prohibit parking. At a minimum, this will generally require painting 7.5 feet on each side of a hydrant and along the curbed radius to a point 20 feet beyond the end of the radius in each direction. Centerline road markings will be required on all roads and streets except local roads. Stop lines will be required on all roads and streets at stop signs. Crosswalks will be required.

2.14 Commercial Driveway Entrances

a. The minimum width of a commercial driveway access shall be 30 feet.

b. Median-divided entrance roads are permitted; however, they must meet a minimum 100-foot depth. The median width may range from 4 feet to 10 feet. The minimum drive-aisle width shall be 14 feet. Any other non-standard design (channelization, right-in, right-out, angled entrances, etc.) must be approved by the City on a case-by-case basis.

c. In all cases, the minimum curb return of radius shall be 25 feet and shall have curbed edge protection. Larger radii are recommended for larger design vehicles.

d. For all commercial driveways having access to higher volume, higher classified roads, the City can require that acceleration/deceleration lanes and bypass lanes with additional right-of-way be provided. When required by the City, a sufficient bypass lane design shall include, as a minimum onto a collector road, a 150-foot departure taper, a 150-foot bypass, a 100-foot transition, and a 150-foot merge taper. When access is onto a minor or major arterial, a 300-foot departure taper, a 300-foot bypass, a 200-foot transition, and a 300-foot merge taper shall apply. The bypass lane shall be a full width lane equal to or greater than the travel lane width.

2.15 Grades

2.15.1 Roadways

a. The minimum allowable grade of roadways shall be 0.50%.

b. The maximum grades of roadways shall be as shown in Table 1.

c. To meet the criteria for cul-de-sacs, the grades across the circular portions of cul-de-sacs shall be flattened when necessary: the grade along the centerline extended across the circular portion of any cul-de-sac shall not exceed a mean of 6%.

d. At an intersection of two roadways, the normal typical section of the priority traffic way shall continue through the intersection without break. The crown of the other traffic way shall be warped from its normal section to connect to the edge of the priority traffic way. Where two traffic ways of equal importance intersect, one shall be considered as a priority traffic way in order to accomplish the foregoing connection, except where the design engineer is unable to determine satisfactorily either one of the intersecting traffic ways as a priority traffic way. In this case, the City shall be consulted.

2.15.2 Intersections with State Roads

Approach grades to Maryland State Highway Administration shall be governed by the State Highway Administration.

2.16 Vertical Curves

a. To avoid an abrupt change in vertical alignment when passing from one grade to another, a vertical curve shall be used at the grade intersection whenever the algebraic difference in the percents of a grade is 0.25 or greater.

b. Elevations on vertical curves shall be computed by the parabolic curve formula, except for rehabilitated streets when it becomes impractical, due to the use of other curves. The elevations of other curves may be scaled when the profile is plotted on a scale of 1 inch = 50 feet horizontal and 1 inch = 5 feet vertical.

c. The minimum length of a vertical curve may include a compound curve, but not a reverse curve, and shall not be less than 100 feet.

d. The parabolic curve is used almost exclusively in connecting grade tangents because of the convenient manner in which the vertical offsets can be computed. Figure 1 in the Appendix provides the Standard Landing Requirements for Local and Collector Streets. A typical symmetrical vertical curve is shown below.

PARABOLIC VERTICAL CURVE

P.V.C. . . . . Point of Vertical Curvature
P.V.I. . . . . Point of Vertical Intersection
P.V.T. . . . . Point of Vertical Tangency

E.	.	.	.	.	External Distance - in feet
L.	.	.	.	.	Length of Curve - in feet
g_1	.	.	.	.	Grade from which stationing starts (in %)
l	.	.	.	.	1/2 or half the Length of Curve
y	.	.	.	.	Offset in feet
x	.	.	.	.	Any Distance from P.V.C. in feet
g_2	.	.	.	.	Grade toward which station heads (in %)

To design the curve for use in profile drawings, first the minimum allowable length of curve must be established. This minimum length is: K (a constant) multiplied by the absolute value of the algebraic difference of the two grades (in percent). Per AASHTO for a design speed of 30 mph in a crest (1) condition K = 30 and a sag (2) condition K = 40. For other design speeds, refer to Table 1.

(1) A vertical crest is the same as a hill or high point, with the extensions of the two tangents forming an angle point up.

(2) A vertical sag is the same as a valley or low point, with the extensions of the two tangents forming an angle pointing down.

Other equations that may be helpful are as follows:

Lmin = K x (gl - g2) = Minimum Vertical Curve Lengths

$$E = \frac{(g1 - g2) \cdot L}{800} \quad = \text{Vertical Offset at P.V.I.}$$

$$r = \frac{g1 - g2}{L(\text{in stations})} = \text{Rate of Grade Change}$$

$$y = \frac{r}{2} x^2 + glx + \text{Elevation P.V.C.} = \text{Vertical Offset of any point X Station from the P.V.C.}$$

In order to determine the high (low) point along the curve, use the equation

$$X \text{ (in stations)} = \frac{-gl}{r}$$

e. An effort shall be made to avoid the placing of horizontal curves along crest vertical curves. Where such design is unavoidable, the sight distance of the vertical curve shall not be less than the horizontal curve sight distance, and the limits of the horizontal curve shall extend beyond the limits of the vertical curve.

2.17 Underdrains

To drain free water from subgrades in excavated areas, underdrains shall be incorporated into the design of new roadways wherever there is a possibility of water undermining the traffic way subgrade. See Standard Details 387.01 and 387.11 of the State Highway Administration for Construction Methods.

2.18 Guard Rail

a. Guard rail shall be erected on roadways at points of extreme hazard to a vehicle leaving the traveled portion of the traffic way. Generally, this potential hazard develops at fills over 8 feet in vertical depth from the edge of the curb or right-of-way to the toe of the slope. Guard rail shall be placed behind the curb and sidewalk.

b. Where roadway construction ends in fill areas, temporary barricade posts shall be erected.

c. For guardrail details, refer to the State Highway Administration Construction Details series 660.

2.19 Sidewalks and Curb and Gutters

Concrete sidewalks and curb and gutters shall be required on both sides of all new roadways, regardless of classification. Refer to the Standard Details in the Appendix of this manual for Construction Details and Location.

2.20 Cross Sections and Quantities

a. Cross sections for roadways shall be taken at least every 50 feet and at all noticeable terrain breaks. The centerline and profile grade line shall be stationed correspondingly.

b. The design engineer shall provide quantity estimates to the City. These estimates shall include all quantities for grading, paving, curb and gutter, excavation, embankment, etc., and shall be tabulated as directed by the City.

2.21 Traffic Impact Studies

2.21.1 Purpose

a. Whenever a proposed project will generate one hundred (100) new vehicle trips in the peak direction (inbound or outbound) during the site peak traffic hour, the applicant shall perform a traffic impact study. Based on this study, certain improvements may be identified to provide safe and efficient access to the development. Studies shall be done on normal weekdays, excluding holidays and when schools are in session.

b. In addition, a traffic impact study shall be prepared whenever either one of the following conditions exist within the impact study area:

1. Current traffic problems exist in the local area, such as a high-accident location, confusing intersection, or a congested intersection which directly affects access to the development.

2. The ability of the existing roadway system to handle increased traffic or the feasibility of improving the roadway system to handle increased traffic is limited, as determined by the City.

3. Study is required as a condition of all annexation and rezoning applications.

2.21.2 Traffic Impact Study

The traffic impact study will include and comply with the requirements as contained in Section 2.2 of the City of Brunswick *Adequate Public Facilities Ordinance*.

2.21.3 Improvements

2.21.3.1 Responsibility for Improvements

The applicant shall be responsible for the improvements required to provide safe and convenient ingress and egress to the development site.

2.21.3.2 Coordination with Municipal Requirements

The applicant shall be responsible for other improvements as may be agreed to with the City of Brunswick or which are required by any municipal adequate public facilities, impact fee or improvement fee, or other ordinance and which improvements shall be installed or paid for by the applicant.

2.22 Utility Trenching, Backfill and Repaving of Roads

2.22.1 Repaving of Utility Trenches

a. All City construction contract specifications shall include a "patch-pave" requirement as follows:

Properly compacted borrow aggregate backfill shall be placed and compacted from 3 inches below the pipe to the bituminous pavement subgrade. The pavement replacement shall consist of a base course of asphaltic concrete of at least a thickness equivalent to the original pavement section, the original wearing course cut back two-feet on all edges of the excavation and a new asphaltic concrete wearing course of at least a thickness equivalent to the original wearing course. Other road pavement sections will receive similar treatment. The base course shall be a minimum of 4 inches and the wearing course shall be a minimum of 2 inches.

b. Patch-paving as outlined above is to be accomplished whether the roadway is to be re-paved or not.

c. House connection installations will require the same specifications for patch-paving.

d. All paving/re-paving work will be accomplished in accordance with the City Road Specifications or Design Manual. A "road cut" permit must be obtained from the City when excavating within an existing City-maintained roadway.

2.22.2 Pipe Bedding, Trench Backfill and Compaction Requirements

a. Bedding: The trench shall be excavated to a minimum depth of three (3) inches below the outside diameter of the pipe, or deeper if so specified. The resultant subgrade shall be undisturbed, or compacted as approved by the Engineer if disturbed. The bedding shall then be prepared by placing a thoroughly compacted aggregage pipe bedding and initial backfill material, consisting of limestone dust, in 6-inch (uncompacted thickness) layers to 2-feet above the top of pipe. Bedding shall provide uniform and continuous bearing and support for the pipe.

b. Backfill Material to Restoration Depth: From two (2) feet above the top of the pipe to restortion depth, the trench shall be backfilled with select aggregate backfill consisting of limestone dust. Backfill in this section of the trench shall be consolidated by tamping in eight (8) inch layers or other approved mechanical methods unless otherwise specified. Any consolidation method utilizing water, such as jetting or puddling, shall not be permitted. Consolidation shall proceed form the center of the trench to the sides to prevent arching. Backfilling shall use equipment and performed in such a manner that will not damage the pipe or joints.

c. Compaction: Use mechanical tampers to compact backfill materials in trench refill operations to produce a density of backfill at the bottom of each layers of not less than 95 percent of maximum density obtained within two (2) percent optimum moisture content as determined by AASHTO T 99. Perform field determinations of density, when requested by the Engineer, in accordance with AASHTO 191. The top twelve (12) inches shall be 100 percent of maximum density in accordance with AASHTO T99. Within State Highways, backfilling and compaction requirements shall comply with those of the State Highway Administration.

In areas other than existing paved streets rights-of-way, future streets rights-of-way, or in any traveled roadway, from a point two (2) feet above the top of pipe to the bottom of topsoil, the backfill shall be placed in not more than twelve (12) inch lifts and solidly compacted by the use of a roller or other mechanical device to a density not less than 90 percent in accordance with AASHTO T 99.

2.22.3 Timing of Patch-Paving and/or Re-Paving

a. Specifications will provide that patch-paving shall be accomplished immediately after backfilling and achieving specified compaction for connection and small extension contracts; and at no greater than seven (7) calendar day intervals for larger projects. Temporary “cold patch” shall be required for patches not immediately patch-paved. The City must be consulted if immediate patch-paving cannot be accomplished. Cold patching must be maintained by the Developer to the City’s satisfaction. The placement of steel plates over trenching may be approved by the City on a case-by-case basis.

b. Re-paving shall be specified to be accomplished in one continuous effort to best assure economy and consistency of quality work.

2.22.4 Traffic Control

All utility construction projects shall have an approved traffic control plan, using requirements of the <u>*Manual on Uniform Traffic Control Devices*</u>.

3.0 CONTRACT DRAWINGS AND DOCUMENTS TO BE SUBMITTED TO CITY

3.1 Contract Drawings

3.1.1 General

a. Roadway layouts shall be prepared on sheets separate from other utilities. These drawings shall be made on standard size tracing mylar film, with titling as required by the City, and shall be rendered in black ink.

b. On all Road and Street projects, including improvements to existing roads and where a subdivision abuts on only one side of the road, cross sections shall be taken in the field. Maximum distance between cross sections shall be 50 feet, with intermediate cross sections taken as needed to show a true picture of the topography. The cross sections shall extend to a point sufficient to determine the slope and other easements.

c. The cross sections shall be plotted on standard cross section paper 10 x 10 graduations to the inch. The scale for plotting the cross sections shall be 1 inch = 10 feet both vertical and horizontal. The original ground line and the proposed road section shall be shown.

d. The plan shall be drawn to a scale of 1 inch = 50 feet or larger. The profile shall be drawn to a horizontal scale of 1 inch = 50 feet or larger and a vertical scale of 1 inch = 5 feet.

e. Drawing numbers of other utilities (water, storm drainage, etc.) being prepared for the development at the same time shall be shown on the plan portion of the roadway drawings.

f. A location map drawn to a scale of 1 inch = 500 feet shall appear on the first drawing of the traffic way drawings. In remote areas, an additional location map on a small scale, such as 1 inch = 2000 feet, shall be required so that existing roadways may be used for orientation reference.

g. The applicant shall submit the appropriate number of copies of all plans, as determined by the Planning and Zoning Office for review by the City and County. Signature blocks shall be provided for signature by the appropriate City Departments and Approval Agencies.

h. The appropriate number of final plans, as determined by the Planning and Zoning Office, shall be submitted to the Office of Planning and Zoning for use by the City in updating the City's maps.

i. As-Built drawings are required to be submitted with the Request for Conditional Acceptance in addition to the Request for Final Acceptance for review and approval. Once approved, the appropriate number of the As-Built drawings on mylar plan sheets with the statement and Engineer's signature, as shown in the Appendix, and City Approval Block shall be submitted to City Hall prior to Final acceptance of the work by the City and on computer or GIS diskette in a format approved by the City Public Works, City Engineer, and the Office of Planning and Zoning.

3.1.2 Plan

3.1.2.1 Street Names

The names of all roadways shall be clearly lettered either along the street centerline or along one property line, whichever location is more convenient; however, all names on each drawing shall be placed in the same relative position.

3.1.2.2 Widths of Right-of-Way, Pavement and Easements

Widths of existing and proposed rights-of-way and pavements for each traffic way shall be shown with dimensioning. Slope easement where established and utility easements and rights-of-way which intersect traffic way rights-of-way shall be shown with dimensioning.

3.1.2.3 Topography

The location of all structures above the subgrade shall be shown, all topography, including poles, trees, fences, hedges, property markers, buildings and other structures. This topography shall be carried at least 100 feet beyond right-of-way lines, 200 feet beyond the ends of roadways or beyond approval limits, and 200 feet in each direction from an intersection. When shown, all measurements for utility structures, poles, trees, fences and hedges shall be dimensioned from the roadway centerline.

3.1.2.4 Coordinates, Bearings, and Ties

a. Bearings of roadway centerlines and coordinates of centerline P.C.s and P.T.s and of intersecting traffic way centerline P.I.s shall be shown along the respective centerlines.

b. In addition to the above requirements, all P.I.s, P.C.s, P.T.s and other points that are needed to re-establish the centerline of the traffic way shall be referenced to permanent features or guarded hub stakes that will not be disturbed prior to the completion of all work.

c. The location and description of all reference points and the distance or angles to the centerline control points shall be shown on all Roads and Street drawings.

3.1.2.5 Horizontal Curve Information

Centerline curve information for each horizontal curve shall be tabulated on the plan in the following manner:

_ = ____° ____' ____" (Angle of intersection)
D = ____° ____' ____" (Degree of curve)
R = ____.____' (Centerline radius)
T = ____.____' (Tangent Length)
L = ____.____' (Length of curve)

_, or Delta, is the external angle of intersection of the tangents at the P.I.

3.1.2.6 Stationing

a. Stationing along the centerlines of tangents shall be in even 100-feet stations, indicated by a small circle and the station number. Stationing along horizontal curves shall be indicated in like manner.

b. P.C.s and P.T.s of horizontal curves shall also be indicated by a small circle on the centerline and their stations shown to the nearest hundredth of a foot.

c. Stations of P.C.s and P.T.s of curbs on circular portions of cul-de-sacs shall be shown on the plan.

d. P.I.s of intersecting traffic way centerlines shall be indicated by a small double circle at the centerline intersection, and the equality to the nearest hundredth of a foot shall be lettered thereunder.

3.1.2.7 Match Lines

Traffic way plan portions shall be continued from one sheet to the next with match lines. In addition, the last 200' of each section of a traffic way plan shall be repeated on the next adjacent section.

3.1.2.8 P.I.s of Curb Lines

The points of intersection of curb lines shall be indicated by small linked crosses and shall be identified thereunder as N.E., N.W., S.W., or S.E.

3.1.2.9 Direction of Drainage

a. Arrows approximately 1/2 inch long shall be drawn around all curb returns and at all critical drainage points to indicate the direction of surface water flow in ditches or gutters.

b. Wherever the slope of a gutter is reversed from the traffic way slope, a note to that effect shall appear on the plan.

c. When an inlet adjacent to a curb return is to be set to such an elevation that it serves as the low point along the curb return, and the grades of the intersecting traffic ways are such that a true picture of the top curb grade in the inlet area is not feasible on the profile, then a note shall appear on the plan stating that the top curb grades in the inlet area shall be set in the field to locate the sump at the inlet.

3.1.2.10 Storm Drainage

a. The design engineer shall indicate on the traffic way plans all of the proposed storm drainage system in the right-of-way. The storm drainage shall be shown schematically by a single dashed line, with inlets and drainage structures and direction of flow indicated.

b. If the storm drain system is of minor nature with no other utilities involved, the design engineer may include the storm drain plans on the roadway plans.

3.1.3 Profiles

3.1.3.1 Centerline Grade

a. The Centerline Grade submitted for approval shall be shown and designated "C_L GRADE." On profiles where the grades are warped, or less than 1 percent slope, spot elevations will be required to clarify the proper grade and direction of slope desired by the Engineer.

b. Circles, as shown in the Standard Symbols, shall be used on profile grade lines to designate vertical curve P.V.C.s, P.V.R.C.s, and P.V.T.s and P.I.s of intersecting top curb lines or centerlines. All percents of grades shall be shown to two decimal places.

3.1.3.2 Previously Established Top of Curb Grade and Centerline Grade

Where a grade line shown on a drawing is taken from a previously established grade, it shall be designated as "ESTABLISHED TOP OF CURB GRADE" or "ESTABLISHED C_L GRADE." The date established and the design drawing number of such previously established grades shall be noted on the profile. On existing pavement, grades shall be field surveyed.

3.1.3.3 Existing Ground Profiles at Centerlines and Property Lines

The profile of the existing ground along the centerline of a proposed roadway and the profile of the existing ground line along property lines shall be shown by dashed ink lines. The existing ground profiles shall be so labeled, and the date and datum of the field survey shall be indicated.

3.1.3.4 Vertical Curves

A vertical curve shall be shown on profiles as a smooth curve between tangents. The correct templates for given vertical curves will be tangent at the P.V.C. and P.V.T. and will pass through the computed middle ordinate elevation at the P.I. Computation of the middle ordinate will be required, except where difficult to compute at unusual intersection situations.

3.1.3.5 Top of Curb Grades for Cul-de-Sacs

Top of curb grades for cul-de-sacs shall be shown independently as profiles running linearly around the perimeter of the cul-de-sac including the approach returns. An additional 100 feet overlap on each end of the linear profile shall be shown.

3.1.3.6 Stationing and Elevations

a. Stations of all points of intersection of curb lines and pavement edges shall be determined at right angles to the centerline. Therefore, a face of curb line shall not be extended to intersect a centerline at a skew in order to establish a station.

b. Throughout profiles, elevations shall usually be shown for each 50 feet station with additional elevations every 25 feet throughout horizontal and vertical curves. Stationing shall be in ink at these points on the profile.

c. Elevations on tangents shall be computed; elevations on vertical curves shall be computed. Elevations shall be shown to the hundredths of a foot.

3.1.3.7 Extension of Profiles

a. At any point where a proposed traffic way is an extension of an existing traffic way, the profile of the existing centerline or top curb shall be shown for at least another 200 feet and the heights of the curb face note. All roadway profiles shall be extended a sufficient distance to define clearly the situation, and this distance shall never be less than 200 feet beyond the approval limits requested, except in the case of a profile terminating at a tee intersection. These profiles shall be independent and shown apart from the proposed top curb profile or profiles.

b. Where profiles must be broken and continued on the same or other sheets, a minimum of 200 feet of profile shall be repeated.

3.1.4 Typical Sections

Typical sections of each type of proposed roadway (i.e. paving width and/or right-of-way width) to be constructed shall be shown once on each set of construction drawings. These sections shall conform with the typical sections shown in the Standard Road and Street Details in the Appendix of this chapter.

3.1.5 Pavement Markings, Signage, Traffic Signals, Street Lights

Plans and details of all pavement markings, signage, street lights, and traffic signals shall be provided. The Developer shall procure and install all signs at the Developer's expense in conformance with the plans prepared by the Developer and approved by the City. Pavement markings shall be installed by the Developer in accordance with the approved plans and this chapter.

3.2 Contract Specifications

Proposed work not covered by the City of Brunswick Standard Specifications for Construction shall be covered in the Frederick County Specifications.

3.3 Estimate of Quantities and Prices

The design engineer shall furnish estimates of all quantities and prices, including a 15% contingency.

3.4 Design Calculations

The design engineer shall submit three copies of design calculations made in connection with the project. The calculations shall be submitted along with the contract drawings.

TABLE 1

Road Classification	Alley	Local		Collector	Minor Arterial	Major Arterial	Service Road
* Minimum R-O-W Width	20'	50' - 60'		60'	80'	100'	40'
Minimum Pavement Width	16' (One-Way)	30' - 32'		34' - 40'	40'	48'	24'
** Curb Required	No	Yes		Yes	Yes	Yes	Yes
Closed Storm Drainage Required	Yes	Yes		Yes	Yes	Yes	Yes
** Sidewalks Required	No	Yes		Yes	Yes	Yes	Yes
Minimum Stopping Sight Distance	150'	150'		200'	300'	350'	200'
Minimum Passing Sight Distance	700'	700'		800'	1000'	1400'	800'
Design Speed	20 mph	25 mph		30 mph	40 mph	50 mph	25 mph
Minimum Horizontal Centerline Radius of Road	150'	150'		200'	600'	700'	150'
Minimum Tangent Between Reverse Horizontal Curves	100'	100'		100'	100'	100'	100'
Minimum 'K' Values for Crest Vertical Curves	30'	30'		45'	55'	85'	30'
Minimum 'K' Values for Sag Vertical Curves	40'	40'		50'	55'	75'	40'
Minimum Roadway Grade	0.5%	0.5%		0.5%	0.5%	0.5%	0.5%
Maximum Roadway Grade	15%	15%	(6% across Cul-de-sac)	10%	7%	7%	15%

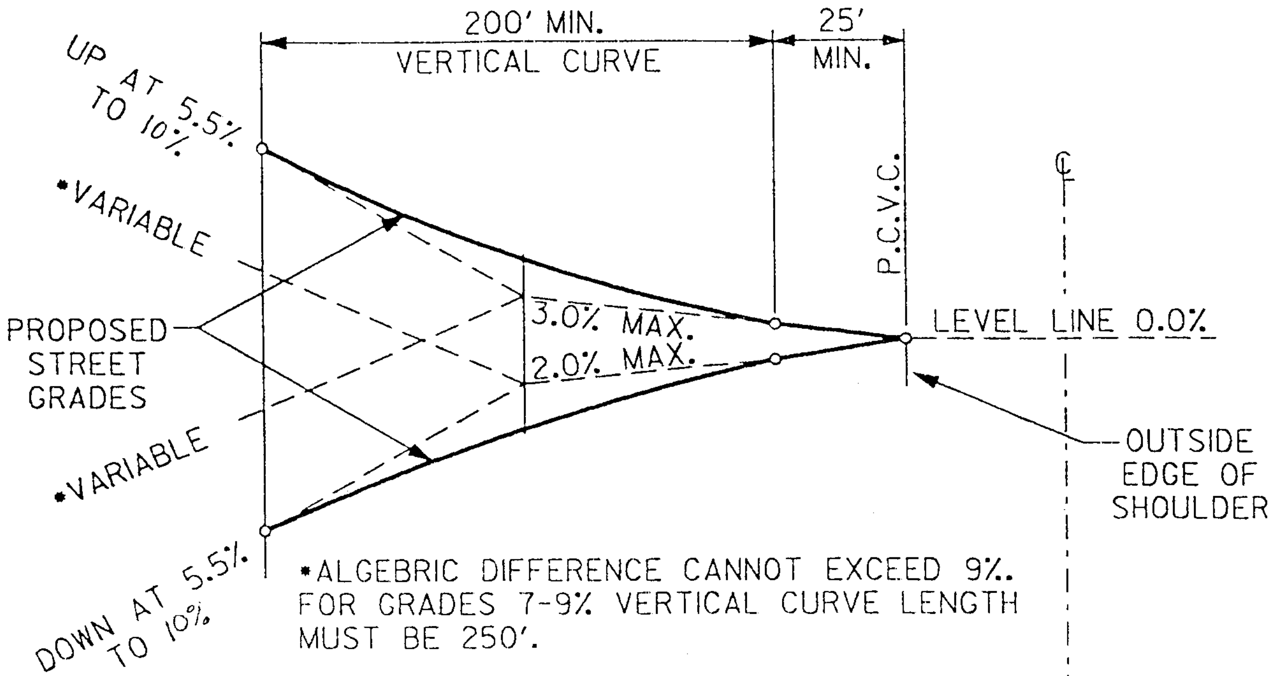
* Additional right-of-way width may be required for turning, bypass, and acceleration/deceleration lanes.
** Curb and sidewalks shall be placed on both sides, when required.

TABLE 2
MINIMUM SEPARATION GUIDELINES

Minimum Distance Between a:	On a Local Street (feet)	On a Collector Street (feet)	On a Arterial Street (feet)
*Access driveways and any public street right-of-way	40	40	40
Local street and a local street	250	300	500
Local street and a collector street	250	400	500
Local street and an arterial street	250	400	500
Collector street and a local street	250	400	500
Collector street and a collector street	300	400	500
Collector street and an arterial street	400	500	750
Arterial street and a local street	300	400	750
Arterial street and a collector street	400	500	750
Arterial street and an arterial street	500	600	750
Private driveway and local street	50	N/A	N/A
Private driveway and collector street	50	N/A	N/A
Private driveway and arterial street	75	N/A	N/A
Commercial entrance and local street	75	75	N/A
Commercial entrance and collector street	100	100	N/A
Commercial entrance and arterial street	125	125	N/A

*Note: Minimum distance between access driveways on any public street is 25 feet.

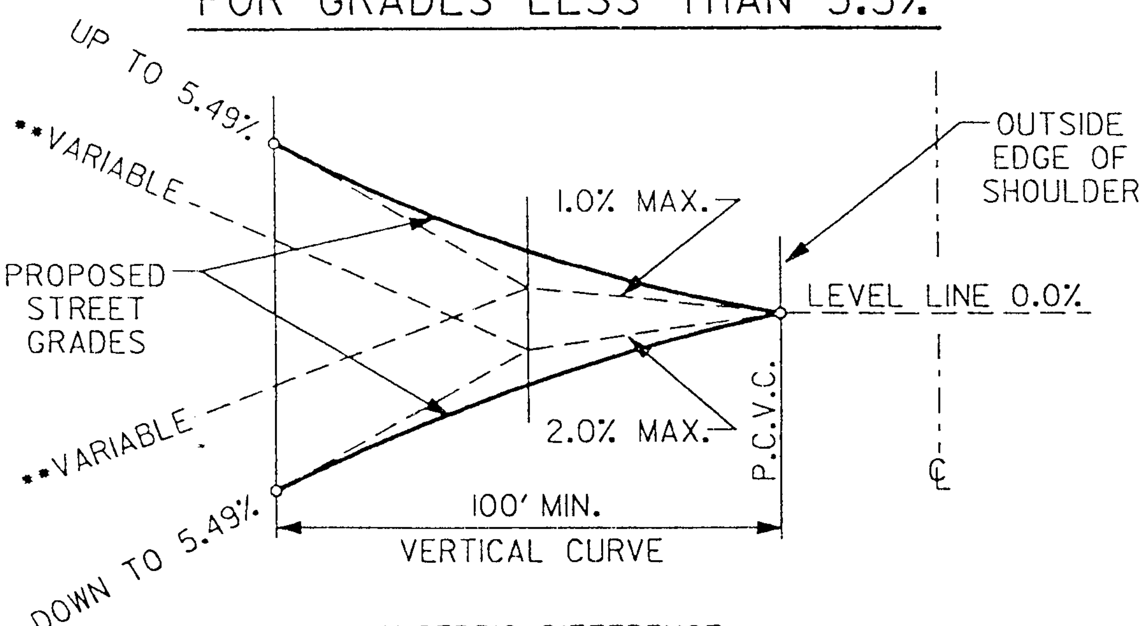
FOR GRADES OF 5.5% TO 10%



*ALGEBRIC DIFFERENCE CANNOT EXCEED 9%. FOR GRADES 7-9% VERTICAL CURVE LENGTH MUST BE 250'.

NOTE: DESIGN GRADES FOR STREETS WITHOUT CURB AND GUTTER SHALL BE AT CENTERLINE OF PROPOSED STREET.

FOR GRADES LESS THAN 5.5%

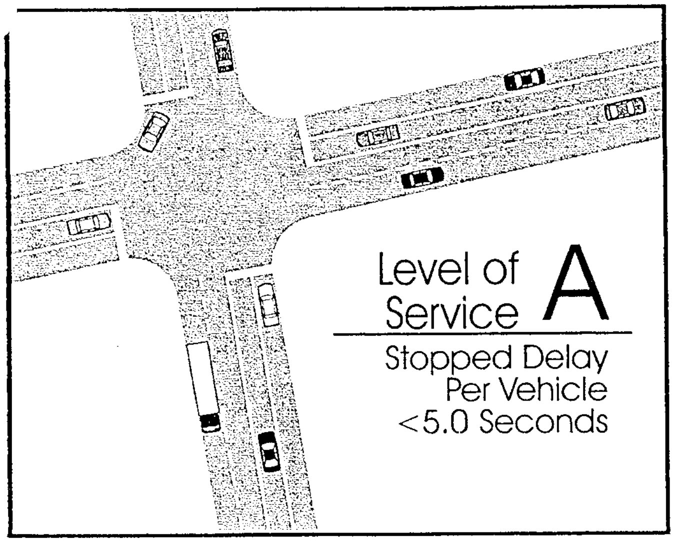


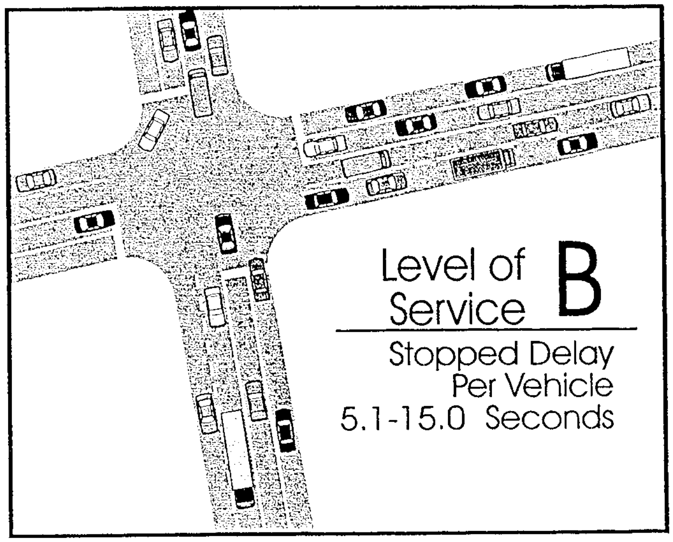
**ALGEBRIC DIFFERENCE CANNOT EXCEED 5%

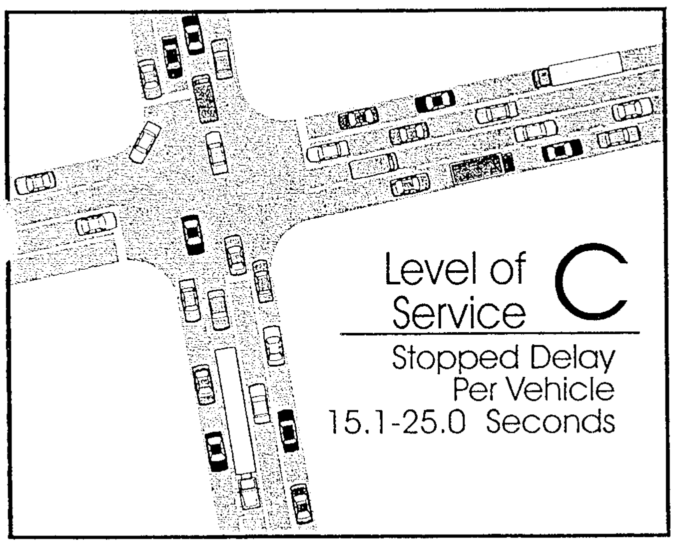
REVISIONS		STANDARD LANDING REQUIREMENTS FOR LOCAL AND COLLECTOR STREETS	DETAIL NO.
DATE	NOTE		
	S-A- 3		DATE:

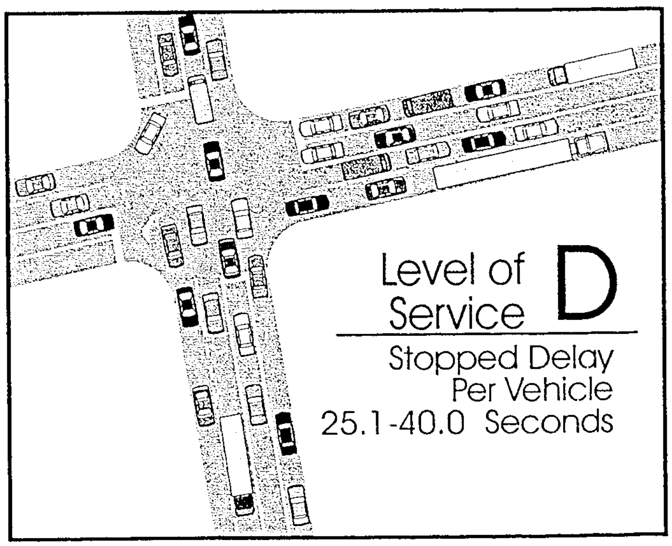
Signalized Intersections Levels of Service

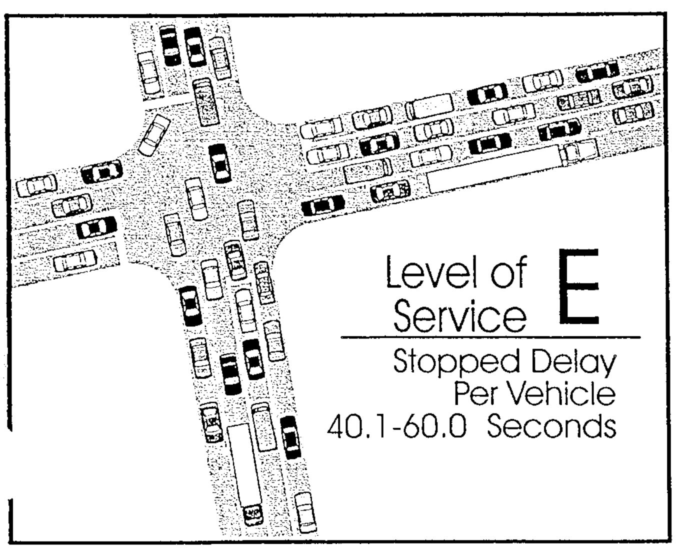
BASED ON "HIGHWAY CAPACITY MANUAL", SPECIAL REPORT 209, TRANSPORTATION RESEARCH BOARD, 1994

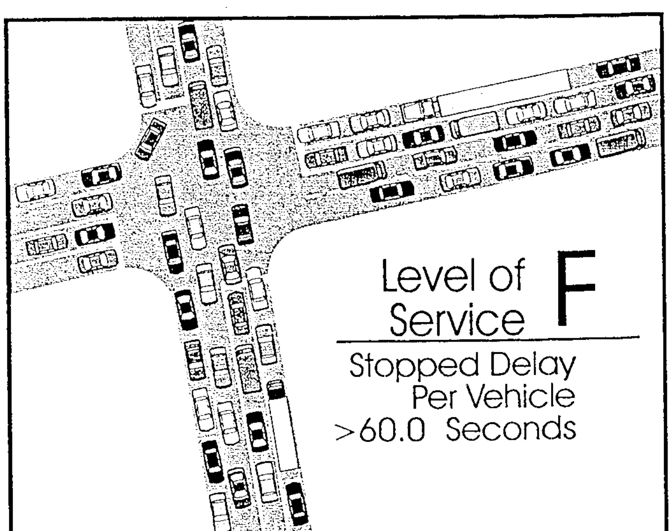












ANALYSIS

LEVEL OF SERVICE CRITERIA

From an operations perspective, the traffic volume passing through an intersection is normally more critical than the volume at a mid-block location. Traffic congestion is more likely experienced where traffic must stop at a traffic signal or stop sign than where it can otherwise flow freely in mid-block. A road which narrows or vehicles turning into or out of on-street parking spaces, or buses stopping to pick up or discharge passengers can slow traffic in mid-block.

The degree of traffic congestion at an intersection can be ranked according to six Levels of Service ranging from A, which is free flowing traffic, to F, which is a forced movement. The six levels as they apply to non-signalized intersections are described in detail below. In this study, the methodology used in determining intersection Levels of Service is the method prescribed in the Highway Capacity Manual, Special Report No. 209 Third Edition, Updated 1994 published by the Transportation Research Board and its software (Highway Capacity Software - HCS) developed by the Federal Highway Administration. In this manual, signalized intersection capacity is evaluated in terms of the ratio demand flow rate to capacity (V/C ratio), while Level of Service (LOS) is evaluated on the basis of average stop delay per vehicle (sec/vehicle). For unsignalized intersections, Levels of Service are evaluated in terms of delay. The generally accepted industry standard is that levels of service A, B, or C are acceptable, D is marginal, and E and F are unacceptable.

Several quantitative methods exist for objectively determining Levels of Service at stop sign-controlled intersections. The 1994 Highway Capacity Manual method was used to calculate levels of service at those intersections where turning movement counts were taken.

Signalized Intersections

Level of service for signalized intersections is defined in terms of delay. Delay indicates the degree of driver discomfort, frustration, fuel consumption, and lost travel time. Specifically, level-of-service criteria are stated in terms of the average stopped delay per vehicle for a 60-minute analysis period.

Delay may be measured in the field, or may be estimated using procedures presented in the 1985 Highway Capacity Manual. Delay is a complex measure and is dependent on a number of variables, including the quality of progression, the cycle length, the green ratio, and the volume/capacity (v/c) ratio for the lane group or approach in question.

Level of Service A describes operations with very low delay, i.e., less than 5.0 sec per vehicle. This occurs when progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

Level of Service B describes operations with delay in the range of 5.1 to 15.0 sec per vehicle. This generally occurs with good progression and/or short cycle lengths. More vehicles stop than for LOS A, causing higher levels of average delay.

Level of Service C describes operations with delay in the range of 15.1 to 25.0 sec per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear in this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.

Level of Service D describes operations with delay in the range of 25.1 to 40.0 sec per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combinations of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

Level of Service E describes operations with delay in the range of 40.1 to 60.0 sec per vehicle. This is considered to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

Level of Service F describes operations with delay in excess of 60.0 sec per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with oversaturation, i.e., when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.00 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

Unsignalized Intersections

Level of service criteria for this methodology are defined as the total elapsed time from when a vehicle stops at the end of the queue until the vehicle departs from the stop line; this time includes the time required for the vehicle to travel from the last-in-queue position to the first-in-queue position.

The average total delay for any particular minor movement is a function of the service rate or capacity of the approach and the degree of saturation. Levels of service range from "A" to "F" and are defined below:

A Little or no delay is expected at an intersection where the delay is equal to or less than 5 seconds per vehicle.

B Short traffic delays may be expected at levels of service B, where the delay is greater than 5 seconds but less than or equal to 10 seconds per vehicle.

C Average traffic delays may be expected at a level of service C, where the delay is greater than 10 seconds but less than or equal to 20 seconds per vehicle.

D Long traffic delays are encountered at an intersection with level of service D, where the delay is greater than 20 seconds but less than or equal to 30 seconds per vehicle.

E Very long delays are encountered at an intersection where the level of service is E, as the delay is greater than 30 seconds but less than or equal to 45 seconds per vehicle.

F When demand capacity exceeds the capacity of the lane, extreme delays will be encountered with queuing, which may cause severe congestion affecting other traffic movements in the intersection. This condition usually warrants improvements to the intersection

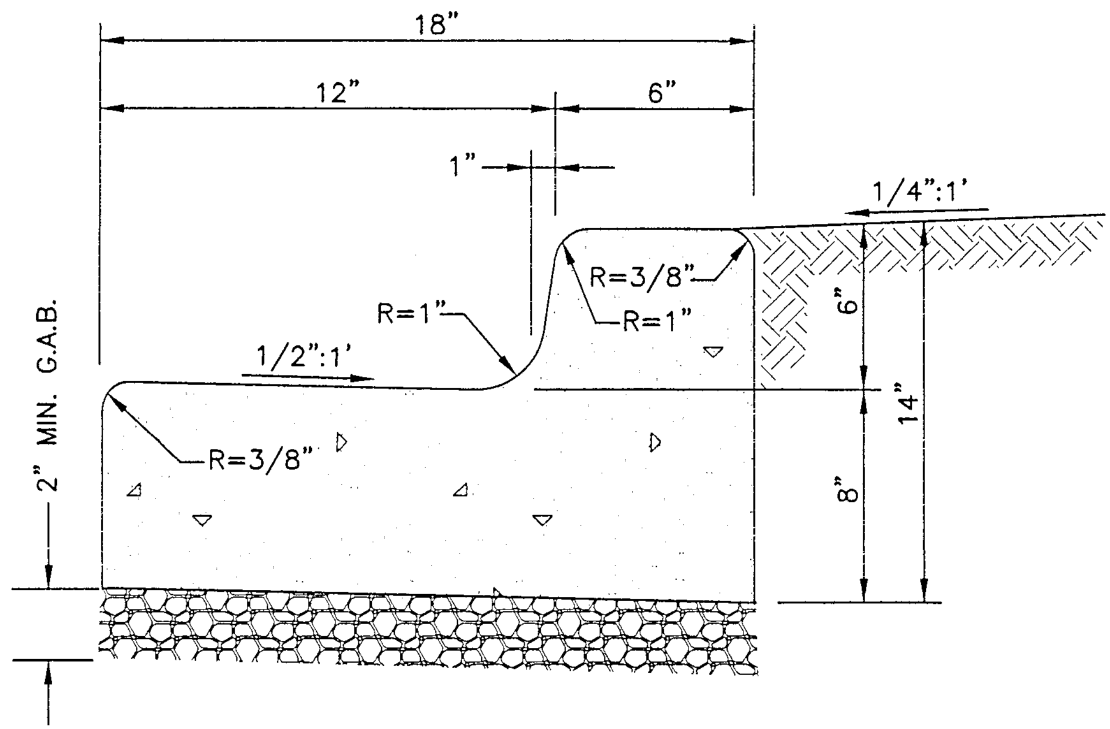
Table 3 shows a summary of the criteria for signalized and unsignalized intersection levels-of-service while Exhibit 2 graphically illustrates this.

Table 3
Level of Service Characteristics

Service (L.O.S.)	UNSIGNALIZED INTERSECTION		SIGNALIZED INTERSECTION	
	Stopped Delay Per Vehicle (Sec)	Expected Delay To Minor Street Traffic	Stopped Delay Per Vehicle (Sec)	Expected Problems To Intersection
A	≤ 5.0	little or no delay	≤ 5.0	very low delay
B	5.1 - 10.0	short traffic delays	5.1 to 15.5	short delay
C	10.1 - 20.0	average traffic delays	15.1 to 25.0	number of vehicles stopping is significant
D	20.1 - 30.0	long traffic delays	25.1 to 40.0	influence of congestion becomes more noticeable
E	30.1 - 45.0	very long traffic delays	40.1 to 60	limit of acceptable delay
F	≥ 45.1	extreme delays - usually warrants improvement to the intersection	≥ 60.1	oversaturated and unacceptable

Source - Highway Capacity Manual - Special Report 209, Transportation Research Board, National Research Council, Washington, DC, 1994

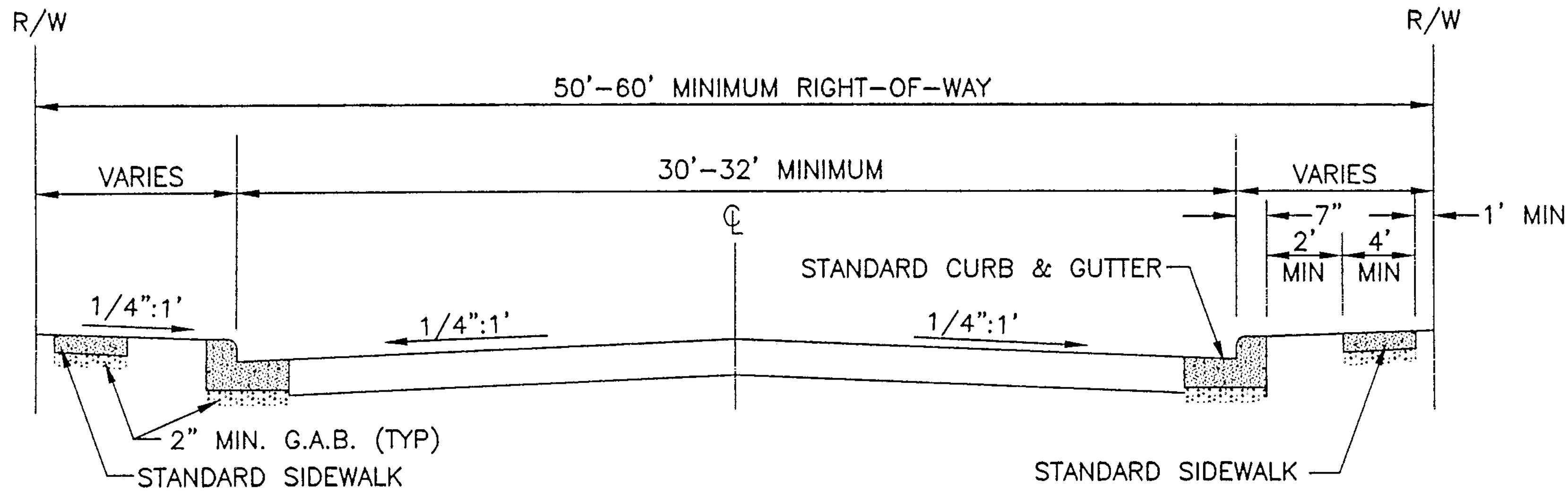
L.O.S. - Level of Service

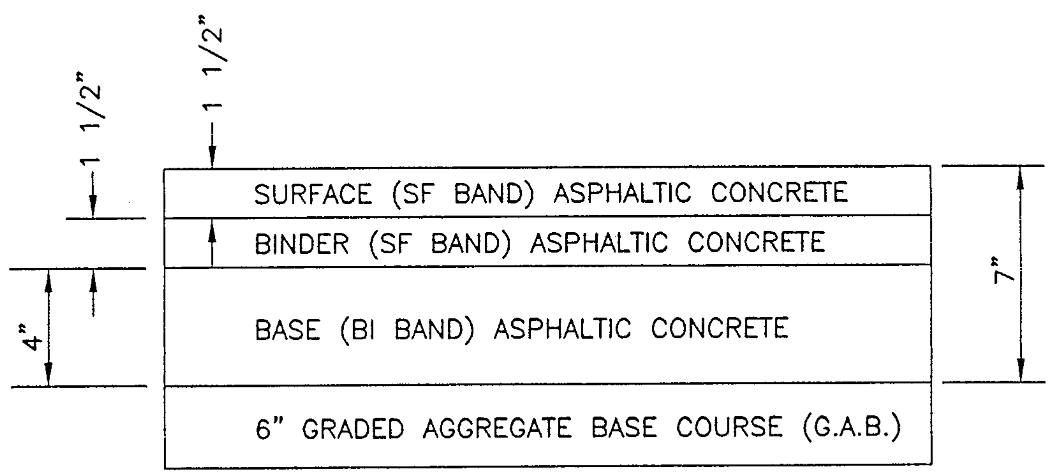


COMBINATION CURB AND GUTTER

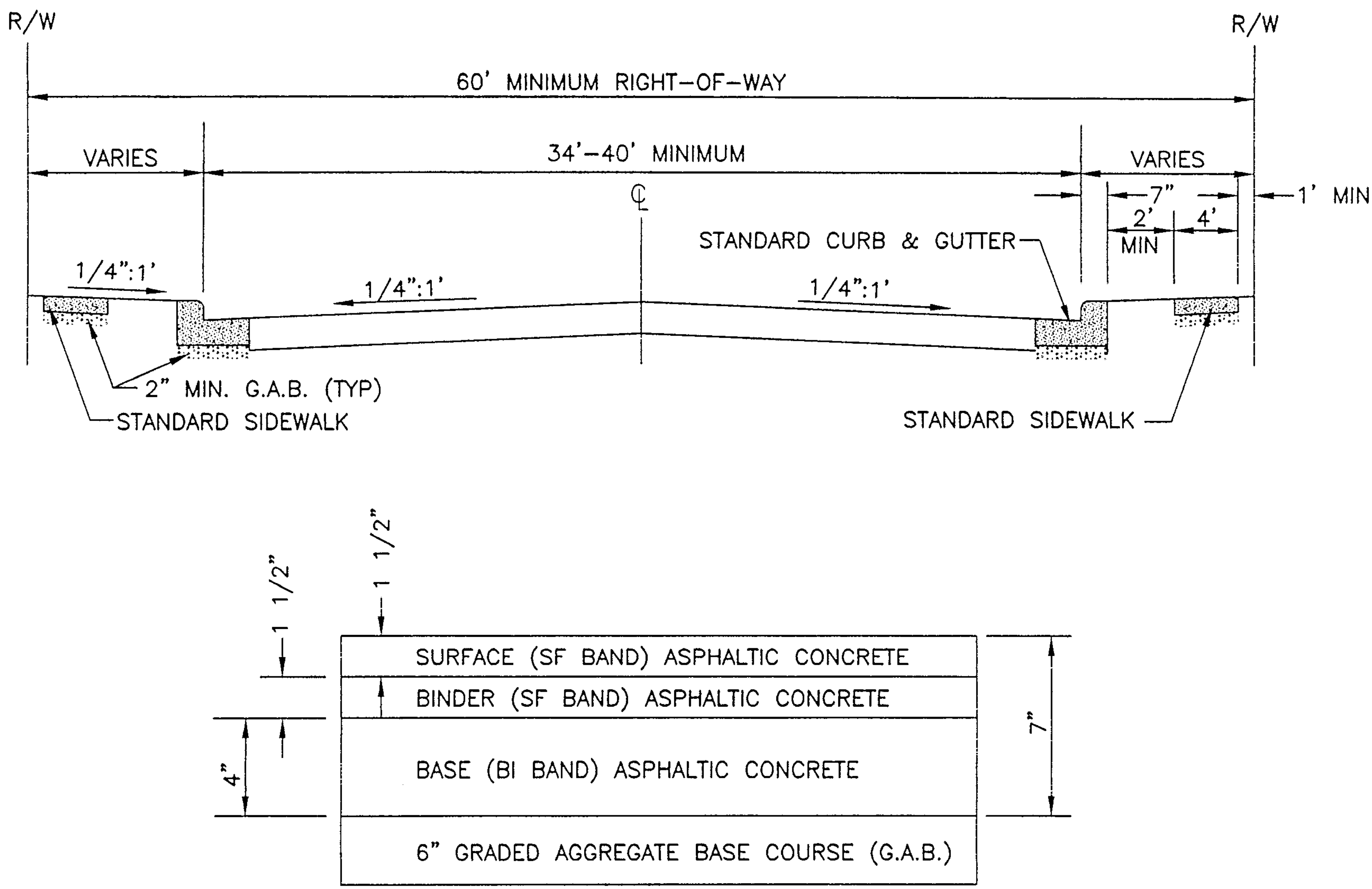
CITY ROAD

CITY OF BRUNSWICK



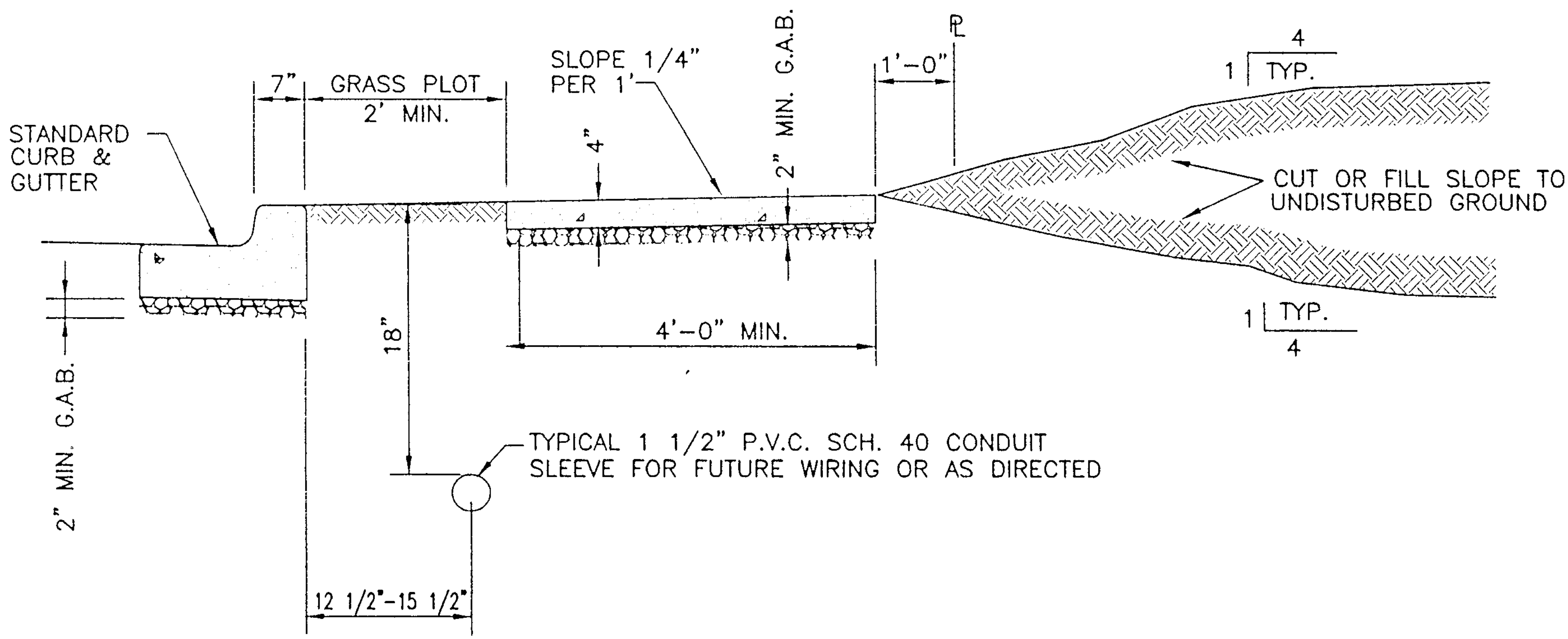


	LOCAL STREET	CITY OF BRUNSWICK

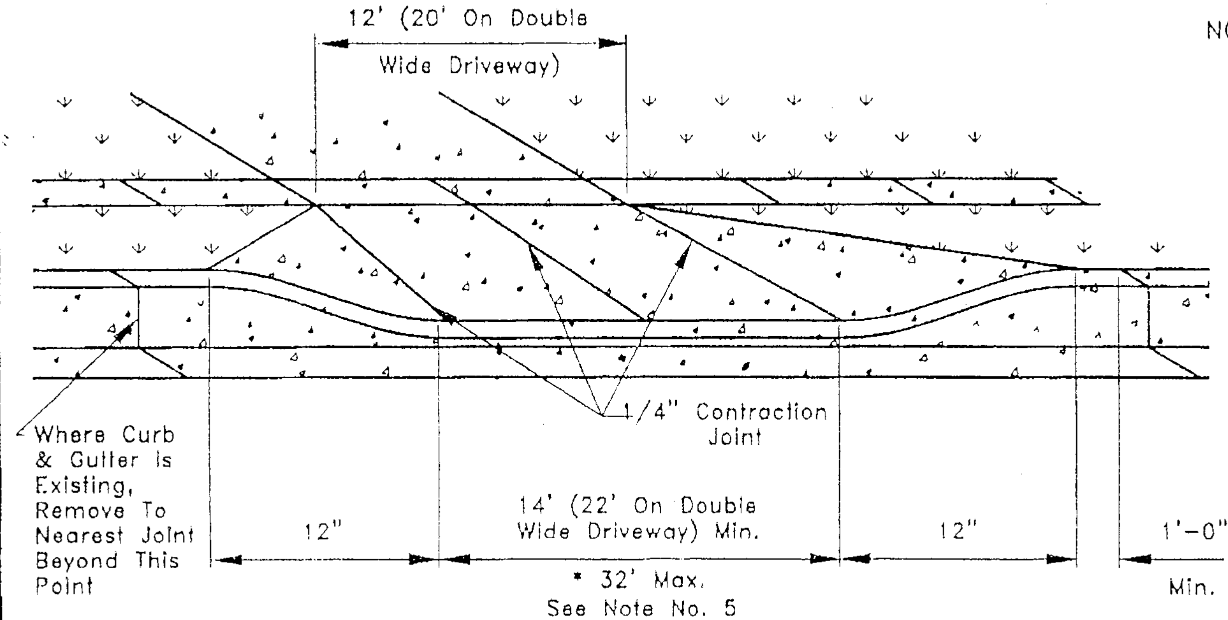


COLLECTOR STREET

CITY OF BRUNSWICK

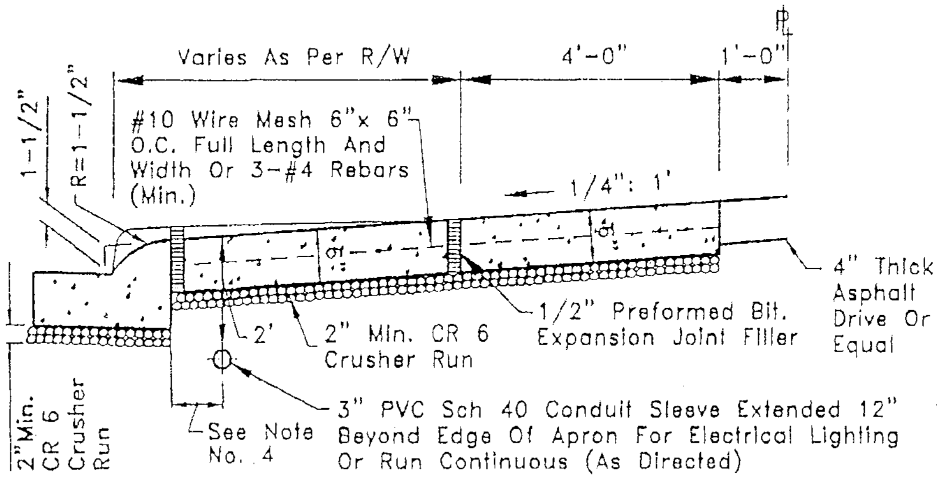


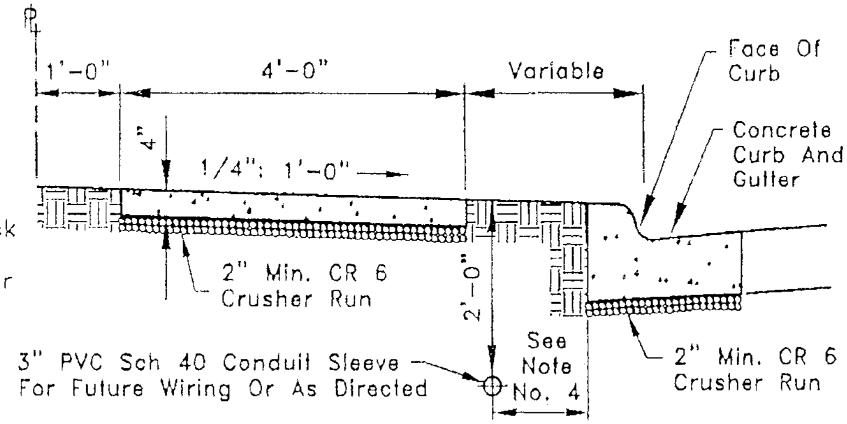
	TYPICAL SIDEWALK INSTALLATION STREET	CITY OF BRUNSWICK



NOTES:

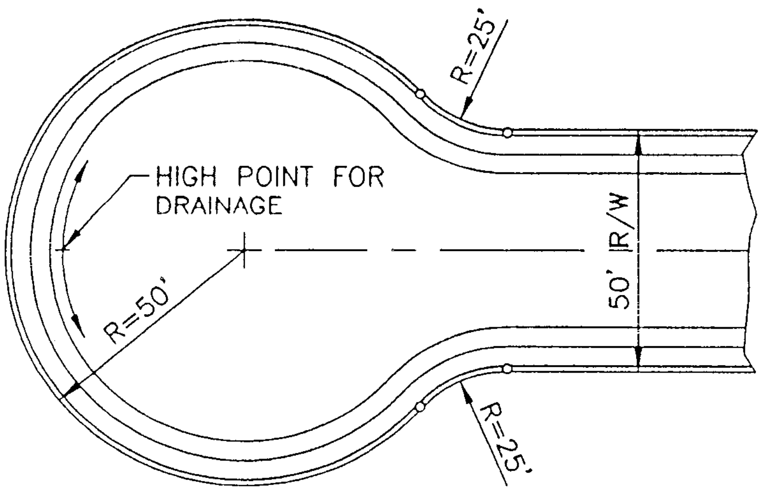
1. Score 1/4" Dummy Contraction Joints At 4'-0" Intervals.
2. Construct 1/2" Bituminous Expansion Joints At 20'-0" (Max.) Intervals.
3. Concrete Shall Be Sprayed With Liquid Curing Compound.
4. 12-1/2" To 15-1/2" See Electrical Details E-3 And E-4.
5. * 32' Maximum Width Is Subject To Approval On A Case By Case Basis And For Commercial Use.
6. Concrete To Be MSHA Mix No. 2.

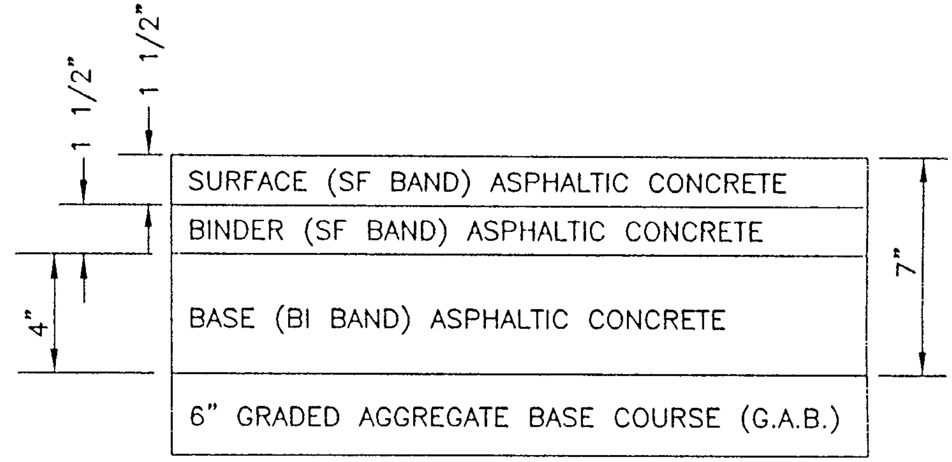


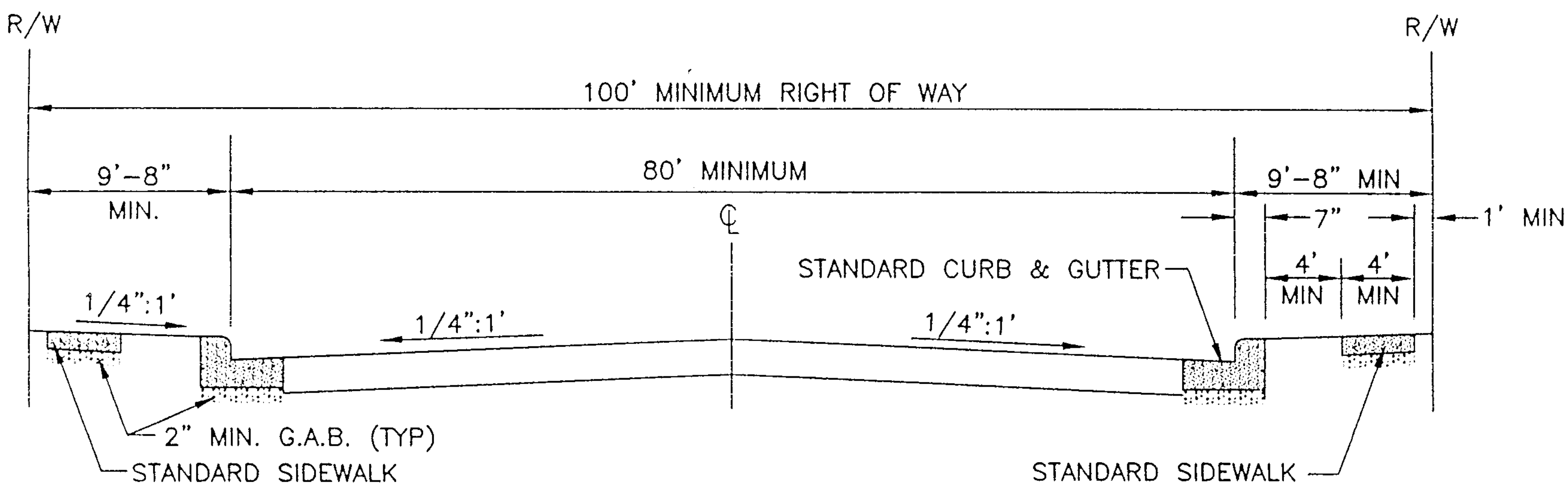


S-7	SCALE: NONE	REVISIONS:	TYPICAL DRIVEWAY-CURB DETAIL AND TYPICAL SIDEWALK LOCATION FOR RESIDENTIAL AND COMMERCIAL ENTRANCES

CAD

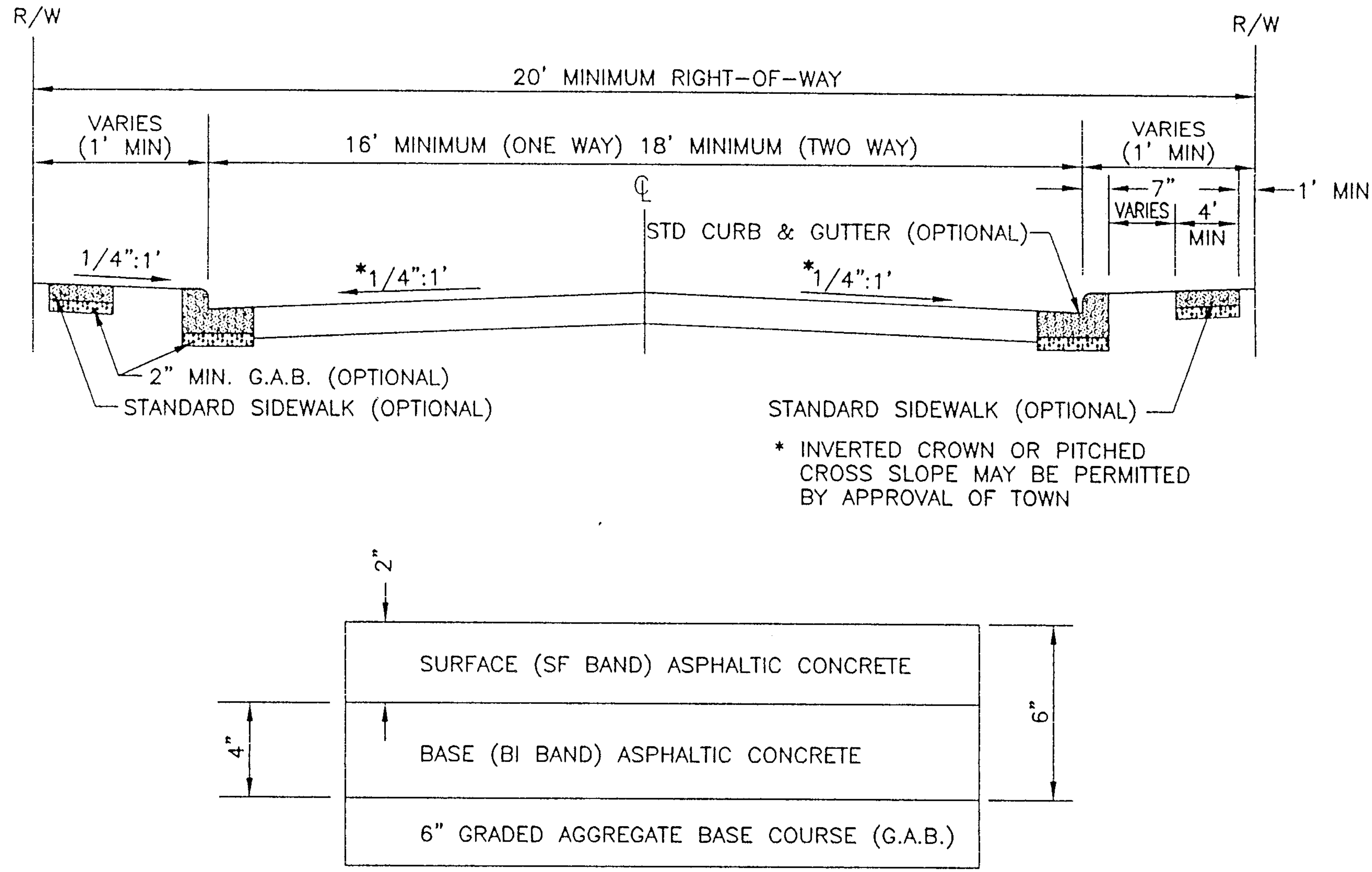




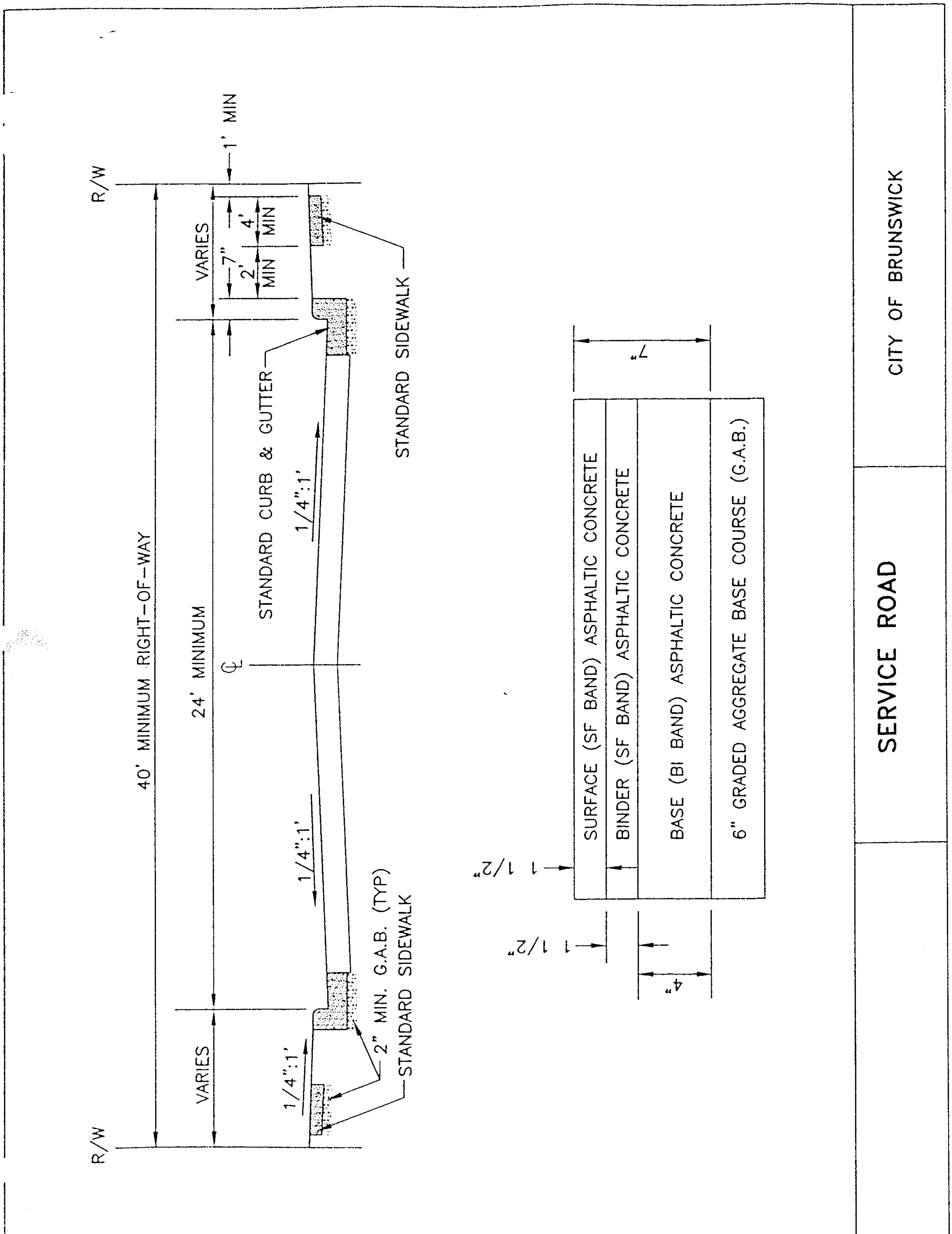


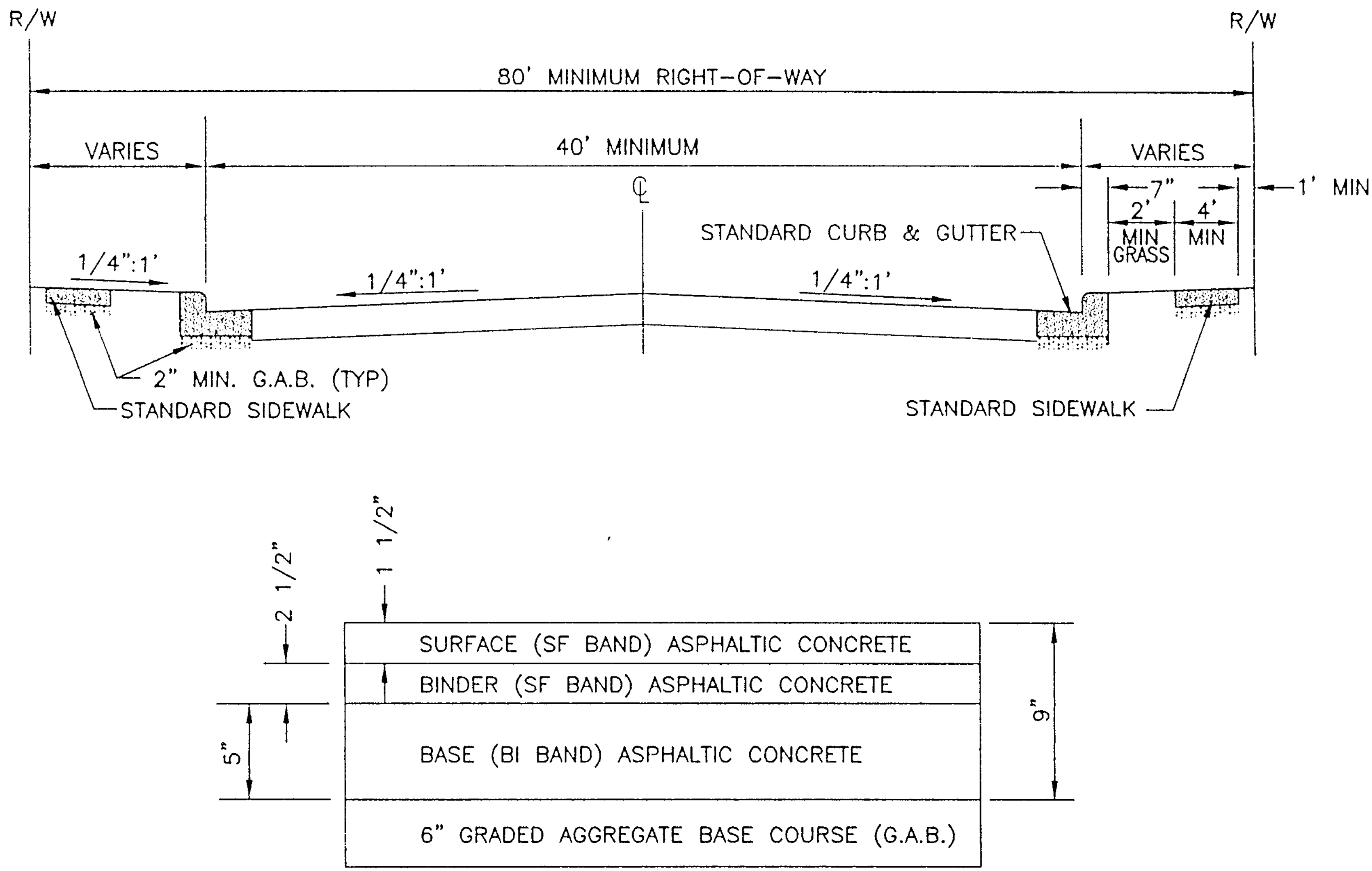
TYPICAL CUL-DE-SAC

CITY OF BRUNSWICK

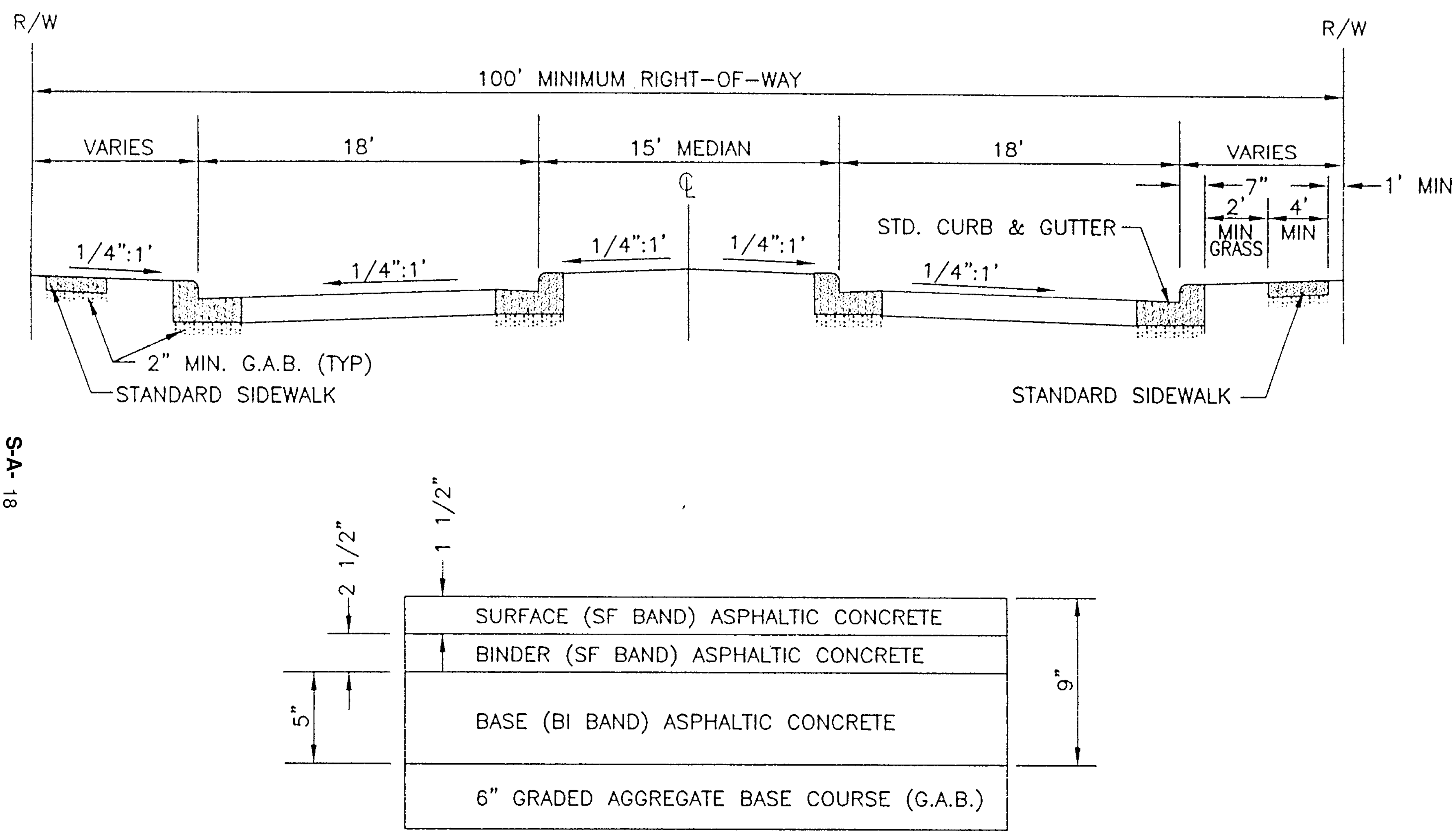


	ALLEY	CITY OF BRUNSWICK


SERVICE ROAD
CITY OF BRUNSWICK
R/W
R/W
40' MINIMUM RIGHT-OF-WAY
24' MINIMUM
VARIES
VARIES
1' MIN
7"
4' MIN
2' MIN
STANDARD CURB & GUTTER
STANDARD SIDEWALK
STANDARD SIDEWALK
2" MIN. G.A.B. (TYP)
1/4":1'
1/4":1'
1/4":1'
℄
SURFACE (SF BAND) ASPHALTIC CONCRETE
BINDER (SF BAND) ASPHALTIC CONCRETE
BASE (BI BAND) ASPHALTIC CONCRETE
6" GRADED AGGREGATE BASE COURSE (G.A.B.)
7"
1 1/2"
1 1/2"
4"

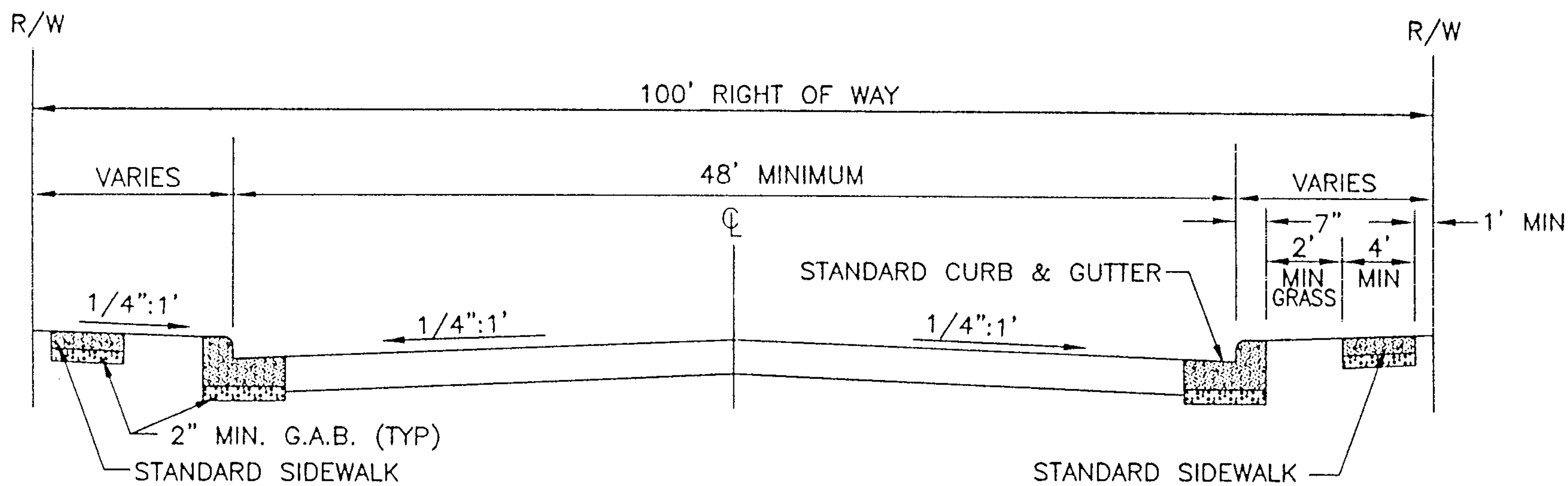


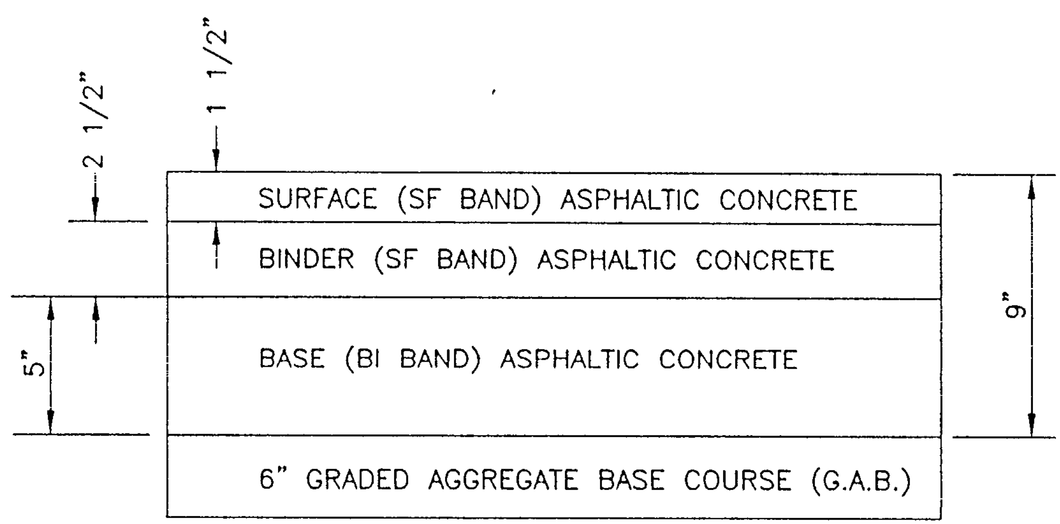
	MINOR ARTERIAL	CITY OF BRUNSWICK



ALTERNATE MINOR ARTERIAL WITH MEDIAN

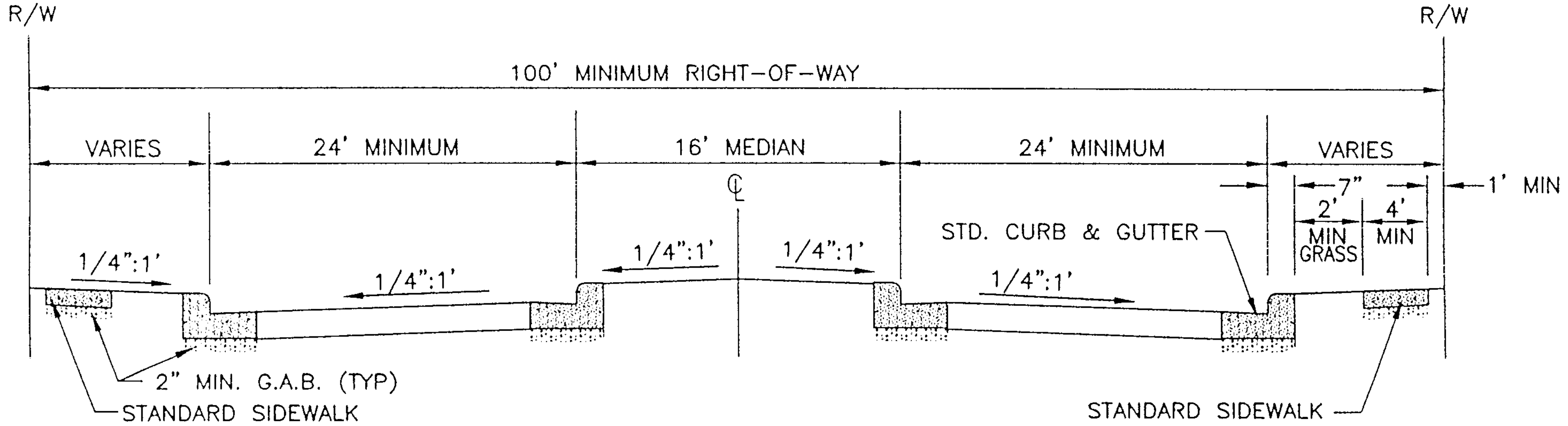
CITY OF BRUNSWICK

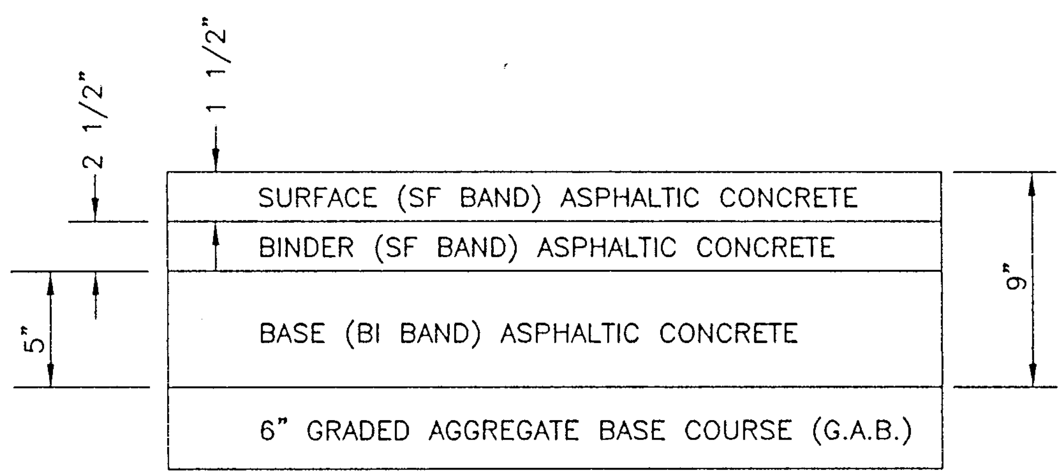




MAJOR ARTERIAL

CITY OF BRUNSWICK





ALTERNATE MAJOR ARTERIAL WITH MEDIAN	CITY OF BRUNSWICK

Appendix A

AS-BUILT DRAWING

I HEREBY STATE, TO THE BEST OF MY KNOWLEDGE AND PERSONAL BELIEF, THAT THE WORK SHOWN ON THESE PLANS WAS CONSTRUCTED TO THE LINES AND GRADES SHOWN.

ENGINEER DATE P.E. NO.

	AS-BUILT DRAWING STATEMENT	CITY OF BRUNSWICK

Appendix B

CITY OF BRUNSWICK, MARYLAND

TRANSIT-ORIENTED DESIGN GUIDELINES

APPROVED BY MAYOR AND COUNCIL

February 14, 2006

TRANSIT-ORIENTED DESIGN GUIDELINES

Prepared by:
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in conjunction with the

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of
Frederick County

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CONTENTS

<u>NOTE:</u> Pages 5-7, 10-11, 13, 16-19, 21-28, 30-41, and 43-45 contain figures and images provided by the Maryland Transit Administration, Maryland Department of Transportation.

INTRODUCTION

Rapid growth and development can create many challenges: traffic congestion, sprawl development, and poor air-quality are a few. These challenges, however, become surmountable when they are viewed as opportunities to find innovative ways to address growth-related transportation issues. The development of communities that are oriented to a variety of transportation modes is an innovative way to address growth issues, to support economic development, and to improve the community's quality of life.

Transit-oriented design (TOD) integrates land use, zoning, and transportation planning elements to promote higher-density, mixed-use development that is easily accessible by various modes of transportation. TOD embraces the concepts of "smart growth" and traditional neighborhood design by encouraging higher-density development in areas with existing public services and by encouraging interconnected street networks. Pedestrian accessibility and street-oriented site design are also important elements of TOD. Another important element of TOD is transit access design, which ensures that development sites are accessible by transit vehicles.

The purpose of these guidelines is to provide developers, planners, and appointed and elected officials with information about the benefits of transit-oriented design, and to encourage the use of design elements that make commercial and residential developments more transit-oriented. These guidelines should be used as a reference tool in the preparation and review of development plans, especially for development that will occur in the County's urbanized areas and other areas that will be served by public transportation.

Goals

Transit-oriented design guidelines will help to accomplish a number of goals and recommendations identified in Frederick County's Countywide Comprehensive Plan and in the Frederick County Transit Development Plan (TDP).

The following goals are identified in the Countywide Comprehensive Plan:

- The County shall accommodate transit, pedestrian, and bicycle access into the design of new development and in the highway planning process; and

- Frederick County shall encourage transit-oriented development adjacent to MARC stations and around the proposed stations along the I-270 transitway.

The Transit Development Plan recommends the following:

- Extend transit services to serve new higher-density residential developments, major new employment areas, and major concentrations of medical offices, health facilities, nursing homes, and other similar destinations;

- Improve transit services to make them more convenient for work- and school-related trips by providing more frequent services, and by minimizing on-board and wait times to the greatest extent possible;

- Provide a high-quality service and market the service so that it is an attractive alternative to persons with the choice of a private automobile as well as those dependent on public transit;

- Encourage transit-friendly design for residential, commercial, and employment development that provides convenient access to transit for pedestrians and persons with disabilities; and

- Establish design standards and site plan review criteria for the County and the City of Frederick to ensure that new developments within the transit service area will accommodate transit vehicles.

Benefits of Transit-Oriented Design

TOD creates an environment that provides transportation choices. The design provides for safe and convenient transit and pedestrian access in addition to automobile access. The availability of transportation alternatives results in economic, environmental, and social impacts that benefit the entire community.

- Transit-oriented design provides the opportunity for people to choose among transportation alternatives, such as biking, walking, driving, or using transit.

- Reducing dependence on the automobile results in reduced traffic congestion, reduced fuel consumption, improved air quality, and a decrease in demand for new roads.

- TOD benefits transit systems by increasing ridership, increasing operating efficiency, reducing operating costs, and improving safety and access for transit vehicles.

- TOD provides greater pedestrian access throughout a development, which creates safer conditions for all pedestrians, including those who use transit. In addition to improved pedestrian access, TOD also provides pedestrian amenities, such as street trees, landscaping, lighting, pedestrian parks, and attractive architectural features. These types of amenities result in improved aesthetics, which often leads to a stronger sense of community and improves quality of life.

- TOD improves access to employment opportunities, housing, and goods and services for the general population. TOD provides significantly improved mobility for the transit-dependent population, which includes individuals who are too young to drive, senior citizens, people with disabilities, and people with low incomes. Frederick County's transit-dependent population is approximately 40% of the County's total population, based on 1990 Census data. This percentage is expected to increase with the aging of the baby-boomer population.

- TOD promotes a street network that is interconnected and direct, with multiple access-points, reducing the cost of providing public services such as transit, school bus service, snow plowing, mail delivery, and trash removal.

- TOD can result in lower development costs by minimizing parking areas and setbacks, reducing the amount of property required for development, and reducing infrastructure costs.

- The availability of multiple modes of transportation can be an economic development marketing tool to attract employers and employees. Also, because TOD results in improved access to employment, businesses located in such developments benefit from a broader labor market and a larger customer base.

- The goals of Maryland's Smart Growth programs are to support and enhance existing communities, preserve natural and agricultural resources, and save taxpayer dollars by reducing the cost of unnecessary new infrastructure. Transit-oriented design enhances and stabilizes existing communities by making transportation alternatives more accessible, convenient and efficient, which increases ridership and maximizes the public investment in transit. Public transit is an amenity which improves the community's quality of life and attracts residential and commercial developers as well as new businesses.

ELEMENTS OF TRANSIT-ORIENTED DESIGN

The four fundamental elements of transit-oriented design are pedestrian and bicycle accessibility, transit-oriented street networks, land use, and site design.

Pedestrian and Bicycle Accessibility

Pedestrian accessibility is one of the most important elements of transit-oriented design. Convenient and efficient pedestrian access promotes walking as an alternative mode of transportation and ensures access to other forms of transportation, particularly transit. Safe, convenient, continuous, and direct pedestrian access ensures accessibility for the transit-dependent population and promotes transit as an alternative for people who choose not to drive.

A 1990 survey indicated that the median distance transit users were willing to walk to a bus stop was just over one-quarter mile. The number of transit trips decreased dramatically when the distance walked to a bus stop was greater than three-quarters of a mile (Figure 1). Therefore, to encourage transit use, pedestrian access and amenities should be provided within a one-quarter to one-half mile radius around bus stops.

Bicycle accessibility is also important. Bike lanes adjacent to roadways and bike paths through new and existing neighborhoods provide a safe and convenient transportation alternative.

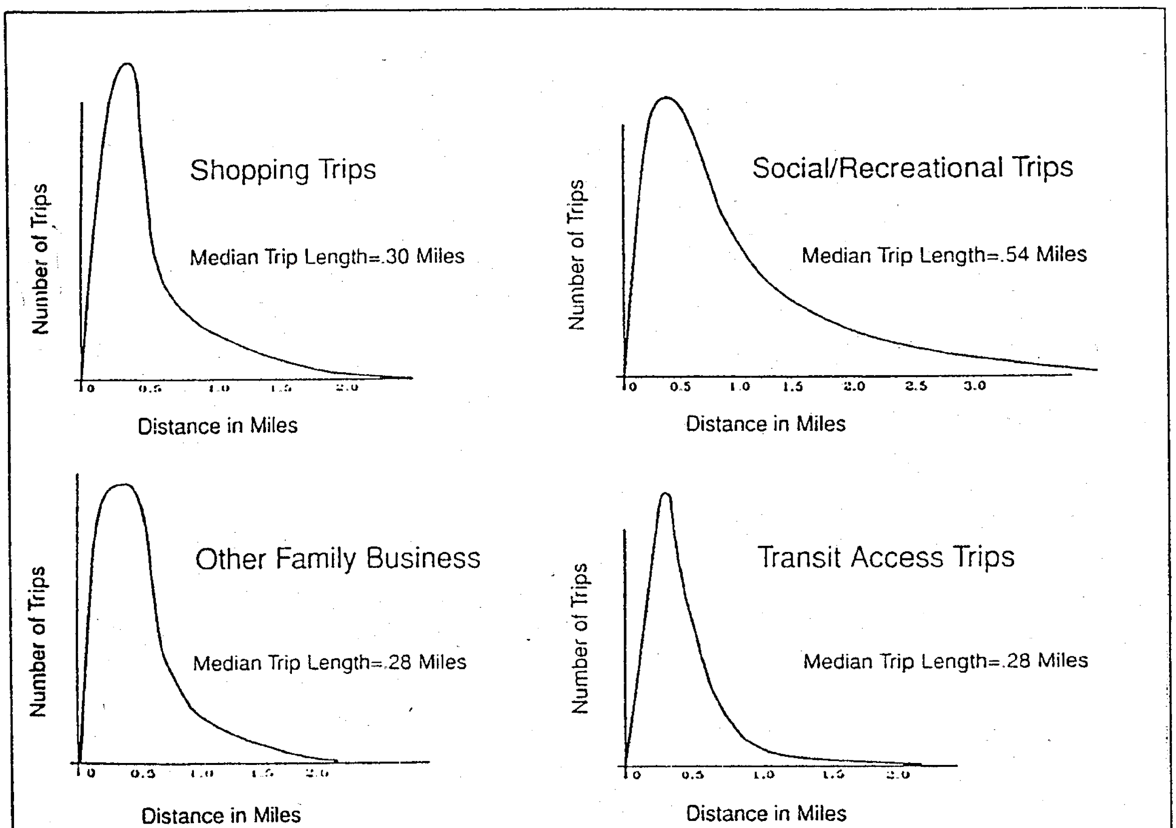
Recommended design elements for pedestrian and bicycle accessibility are:

- ❖ safe pedestrian crossings at intersections;
- ❖ sidewalks provided along all newly constructed streets and added to existing streets where gaps exist. Sidewalks should be a minimum of five (5) feet wide with a minimum three (3) foot planting strip (wider along busy arterial streets) between the sidewalk and the curb for safety purposes;
- ❖ bicycle lanes adjacent to roadways and bike paths through new and existing neighborhoods, particularly in areas near major transit stops;
- ❖ adequate street lighting for safety and convenience;
- ❖ landscaping and street trees for aesthetic purposes;
- ❖ awnings and overhangs for weather protection and other architectural features for aesthetic purposes;

- pedestrian parks, benches, and other amenities to generally improve the pedestrian environment; and

- bicycle racks or lockers at major transit stops to encourage bicycle riding as a transportation alternative.

Figure 1
Relationship between Walking Distance and Trip Purpose

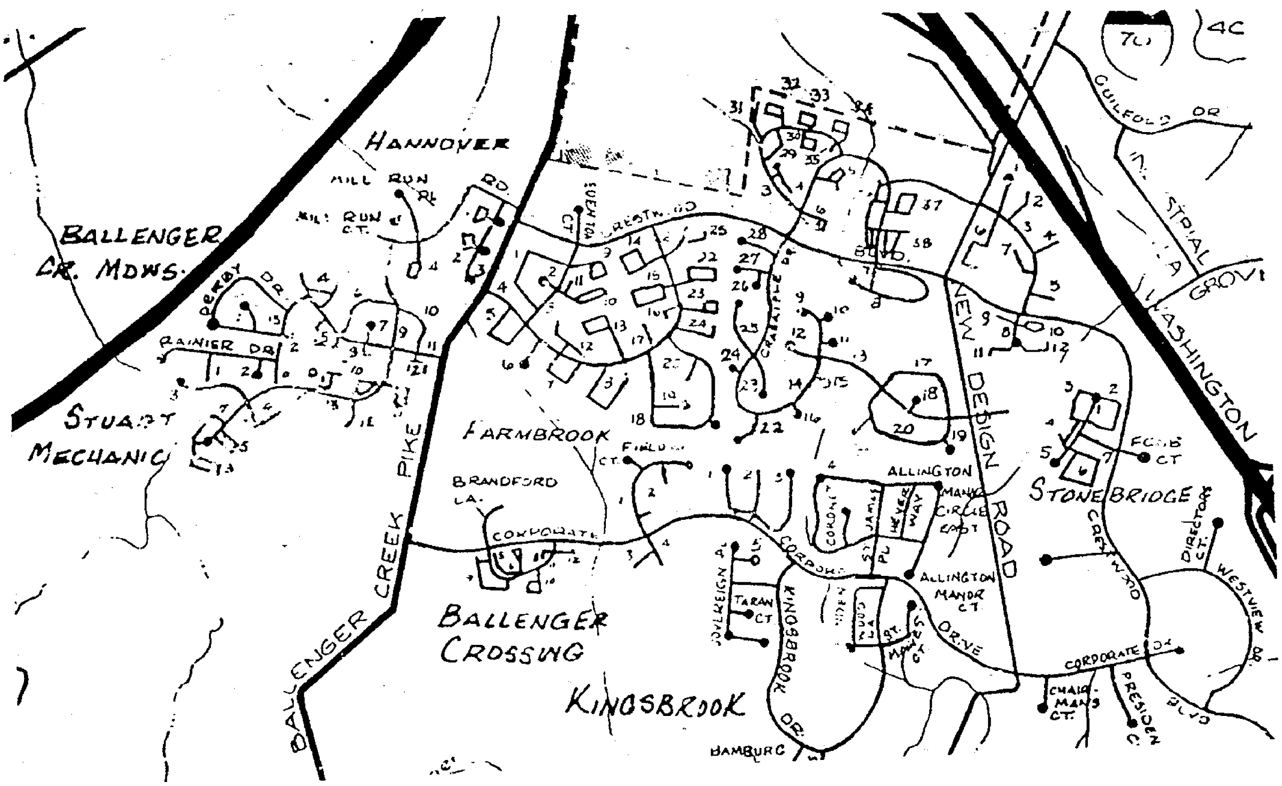


Source: 1990 Nationwide Personal Transportation Survey

Transit-Oriented Street Network

Pedestrian access is predicated on a street network that is interconnected, and provides direct and convenient access to various uses or transportation alternatives, such as transit stops. Over the last 30 years, the typical street pattern used in residential developments included a spine arterial road intersected by few curvilinear local streets that terminate in dead ends and cul-de-sacs. Often, streets constructed in new, adjacent developments do not connect with existing streets, exacerbating the problem of disconnected streets. This type of street pattern reduces pedestrian access and is not conducive to efficient transit operation, because buses must be routed through individual neighborhoods or there must be more stops along the spine road to adequately serve the area, adding considerable time and distance to the bus route.

Figure 2
Disconnected Street Pattern



Transit-oriented street networks include interconnected street patterns, which provide direct pedestrian access through neighborhoods to a centrally located bus stop. Street networks with characteristics of modern, curvilinear networks, as well as grid networks, may be considered transit-oriented as long as pedestrian paths creating short, direct connections are provided.

Figure 3
Interconnected Street Network

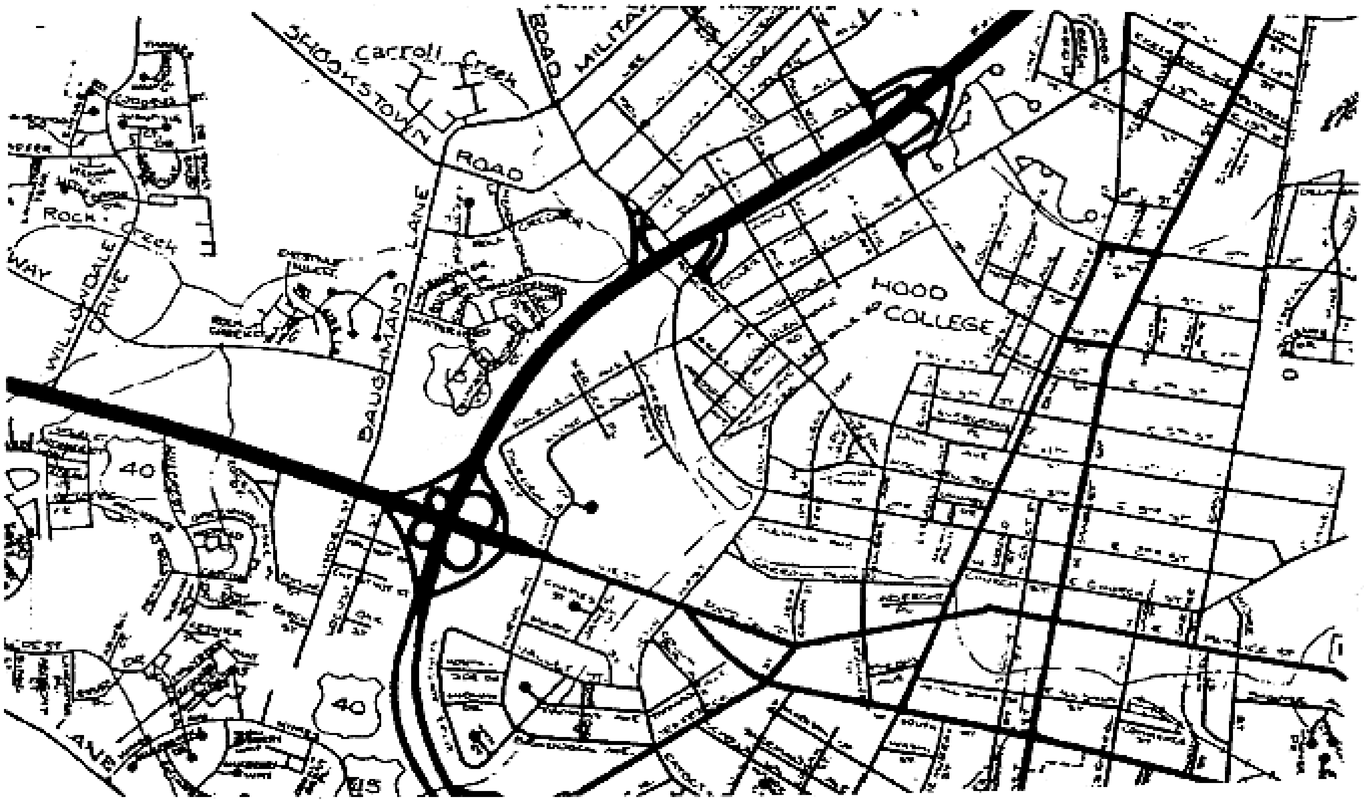


Figure 3 is an example of a street network that provides several advantages for transit service. The interconnected street pattern provides multiple routes for pedestrians and direct access through the neighborhood to the bus stop, allowing a centrally-located bus stop to serve a greater area.

In commercial and employment areas, a transit-oriented street network would include service roads or public streets that run parallel to heavily-traveled, high-speed, multi-lane arterials, providing a safe location for bus stops and convenient pedestrian access to businesses. Because of the safety hazards of locating bus stops on arterial roads, transit vehicles currently must enter shopping centers and business parks in order to serve them, which adds time and travel distance to the bus route, reducing operating efficiency and customer convenience.

Land Use

The two most critical land use issues in transit-oriented design are density and mixed-use developments.

Density - Studies show that transit use increases with higher land use density. Higher density residential uses, such as multi-family developments, generate more transit ridership because the population of multi-family developments tends to have lower automobile ownership rates and lower family incomes. Developing higher density residential uses along existing and planned transit routes not only ensures access to transit, but is consistent with “smart growth”, which encourages development where services already exist.

One way to ensure that higher density residential uses are developed in the transit service area is to require minimum, rather than maximum, densities. To achieve minimum densities, lot sizes for single-family detached units can be reduced, and units can be clustered. Zero lot-line provisions can be applied in smaller-lot single-family subdivisions. Also, a variety of attached housing types could be utilized to achieve higher densities. Implementing a critical areas density transfer program and providing incentives such as density bonuses and fast-track permitting will result in transit-oriented development.

Mixed-Use Development - Transit-oriented design promotes development that includes a mix of residential, commercial, and employment uses. In more urban areas, these uses may be mixed within a single building, while in suburban areas the different uses may be clustered in a group of several buildings.

The primary benefit to mixed-used developments is that the close proximity of residential, commercial, and employment uses encourages the use of alternative modes of transportation and reduces dependence on the automobile.

Impact fee waivers and fast-track permitting could be provided as incentives for mixed-use developments.

Site Design

Commercial and office developments are typically separated from the street by vast parking areas that offer poor pedestrian access and discourage transit use. Pedestrians perceive walking across large parking lots as unsafe and inconvenient. Furthermore, it is time-consuming and inefficient for transit systems to drive through every strip mall and office park in order to stop at safe locations that are convenient for transit users.

Local zoning ordinances tend to require that shopping centers and office buildings have adequate parking to handle peak usage, which may only occur once or twice for a limited time throughout the year. A transit-oriented approach imposes parking maximums rather than parking minimums to limit the amount of parking for each use, so that parking provided is adequate to accommodate average demand. On-street parking should be allowed where practical to accommodate higher-than-average demand. Finally, encouraging shared parking among uses reduces the amount of parking area required, while providing plenty of parking around the clock. For example, in a mixed-use development that features shopping, office space, restaurants, and residential uses, the same parking spaces that are occupied during the day by office employees can be used in the evening by residents and patrons of the shopping center or restaurants.

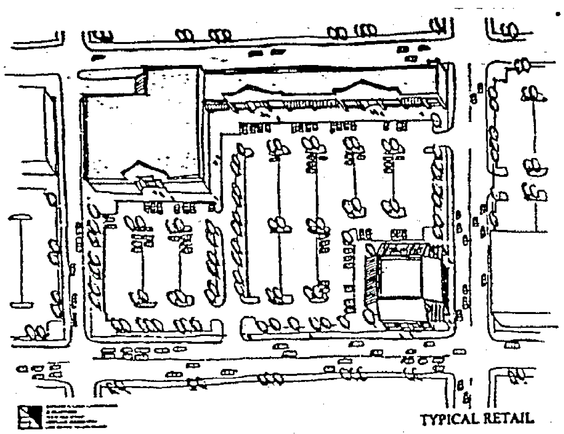
To encourage transit use, entrances to commercial and office buildings as well as multi-family residential developments should be oriented to the street to minimize the distance between the entrance and sidewalks or bus stops. Parking should be located to the sides and rear of the site. If parking must be located between the building and the street, an additional sidewalk connecting the entrance of the building to the street sidewalk should be provided.

Transit-oriented design encourages the use of the following elements:

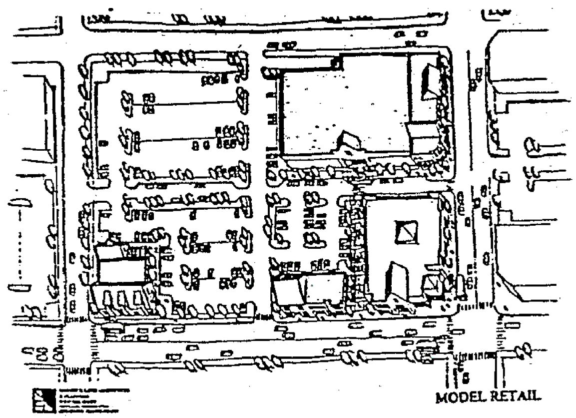
- ❖ shared parking between adjoining uses;
- ❖ on-street parking where practical;
- ❖ minimum parking requirements that more closely match demand; and
- ❖ maximum parking limits.

The following figures are examples of typical shopping center and office park layouts and how they can be redesigned to be more transit-oriented.

Figure 4
Commercial Development

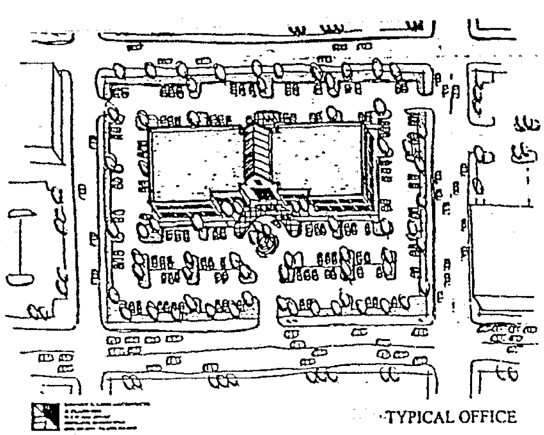


Typical one-story retail development with 4.5 spaces per 1,000 sq. ft. has a floor area ratio of 0.25.

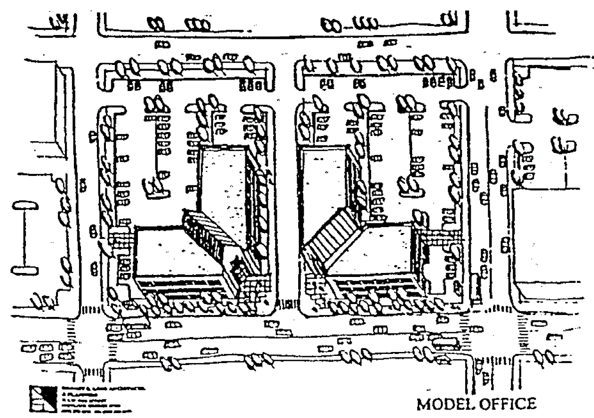


Increasing the height to two stories along one street and providing 3.5 spaces per 1,000 sq. ft. doubles the floor area ratio to 0.50.

Figure 5
Office Development



Typical two-story office development with surface parking has a floor area ratio of 0.5.



Increasing the height to three stories and reducing parking to three spaces per 1,000 sq. ft. doubles the floor area ratio to 1.0.

TRANSIT ACCESS DESIGN STANDARDS

The Maryland Department of Transportation and the Mass Transit Administration have established standards for the design of fixed-route bus stops, turnouts, and shelters, as well as turning radii at intersections. The transit access design standards were published in the *Maryland Transit Guidelines* (May 2002) for use by the development community in designing transit-accessible developments. Similar design standards should be incorporated into the appropriate local regulatory documents.

Design standards to ensure access by smaller vehicles used for paratransit services should also be considered. Facilities and developments that serve senior citizens and people with disabilities who may use paratransit services should be designed to include canopies or covered areas at entrances that are tall enough and wide enough to accommodate transit vehicles and to provide adequate weather protection for passenger loading. Parking areas should be designed so that smaller transit vehicles are able to enter and exit easily and quickly without having to back up and without impeding the normal traffic flow.

Vehicle Specifications

TransIT currently has a fleet of 30-foot buses, 28-foot buses, small (<24') buses, and vans/minivans. TransIT plans to add new 30' buses to its fleet in the coming years. The specifications/dimensions of these vehicles are noted in Figure 6. Turning radii standards provided in Appendix C are for buses up to 40 feet in length.

Figure 6
TransIT Vehicle Specifications

	Transit Bus	Shuttle Bus
Maximum Length	32'	24'
Maximum Width	96"	96"
Maximum Height	120"	115"
Weight (without passengers)	24,500 lbs.	10,500 lbs.
Turning Radius	33'7"	----

Bus Stops and Passenger Shelters

Bus stop and passenger shelter locations are based on the level of ridership activity at a given location. If the level of activity is high, or if the stop serves a major activity center, such as a hospital or community center, consideration should be given to installing a passenger shelter. New developments along existing or proposed transit routes should include appropriate locations for bus stops with paved passenger boarding areas and, in areas with high ridership, passenger shelters. At layover points or at stops with higher ridership activity, concrete bus pads (Appendix B) should be incorporated into the design and construction of new streets.

Bus stops should be located where it is safe and convenient for passengers to board. Spacing of bus stops depends on the density and characteristics of the area served. In high-density areas, bus stops may be located every 450 feet; while in suburban areas, bus stops may be located every 1000-1200 feet.

Bus stops at large commercial and office developments should be centrally located or located on streets, rather than within the developments, to maximize the use of the stop and to minimize vehicle travel times and distances. Also, locating bus stops on the street rather than in parking areas minimizes interaction between transit vehicles, other motorists, and pedestrians.

Passenger shelters should also be located at stops with higher ridership activity to protect passengers from inclement weather and to provide them with a safe place to wait for the bus. Shelters should be oriented so that pedestrian and vehicular sight distance is not impaired and so that passengers within the shelter are able to see and be seen by approaching buses. Shelters should be enclosed on three sides, and should be positioned at least five feet from the curb, but near enough to provide quick access to the bus door. The open side of the shelter should be oriented toward the street. Additionally, passenger shelters must be handicapped accessible, and should be installed on a concrete pad. Walkways connecting the sidewalk, shelter, and street should be provided. To give TransIT a more visible identity, it is recommended that the passenger shelters have a unique design that is reflective of local architecture.

Appendix B identifies alternative bus stop locations and typical dimensions and layout for passenger shelters.

Additional amenities that may be provided in and near bus stops and passenger shelters are landscaping, public telephones, mail boxes, newspaper vending boxes, lighting, seating, and trash receptacles. Business and residential associations are encouraged to “adopt” shelters by providing and maintaining the shelter and passenger amenities, such as the landscaping and trash receptacles. Well-maintained bus stops and passenger shelters encourage transit use and enhance the aesthetics of the surrounding area.

IMPLEMENTATION OF TRANSIT-ORIENTED DESIGN STANDARDS

Effective transit-oriented design standards are implemented not only through comprehensive plan policies, but through inclusion in development regulations and consideration during the development review process. Currently, Volume 1 of the 1998 Frederick County Comprehensive Plan and the 1999 Frederick County Transit Development Plan recommend the adoption of transit-oriented design standards. However, in order to compel developers to use TODs, the goals and recommendations of the comprehensive plan must be translated into the development regulations of the zoning ordinance, subdivision regulations, and/or the design manuals.

The following elements of design are examples of those currently regulated by the zoning ordinance, subdivision regulations, and design manuals. These elements should be reviewed and revised to accommodate transit-oriented design standards.

Figure 7
Elements of Design

- Densities
- Setbacks
- Clustering
- Mixed-Use Developments
- Sidewalks
- Other pedestrian access
- Other pedestrian amenities
- Street landscaping
- Street lighting
- Parking
- Parking lot landscaping
- Parking lot lighting
- Alleys
- Cul-de-sacs
- Dead-end streets
- Entrance design/turning radii
- Lane widths
- Roadway paving/grades
- Intersection design

Until transit-oriented design is integrated into the City's development policies, the Transit Accessibility Checklist (Appendix A) should be utilized by local developers, planners, and appointed and elected officials to determine if proposed developments are transit-accessible.

CONCLUSION

Continued growth and development will bring challenges to Frederick County and the City of Brunswick that can be addressed through a shift in focus from automobile-oriented development to transit-oriented development in the County's urbanized areas and areas within the City of Brunswick that will be served by public transportation. Transit-oriented design will provide access to alternate transportation modes and will ensure that community transportation and other public services can be provided in an efficient manner by minimizing travel times and miles.

Transit-oriented design embraces the concepts of "smart growth" and traditional neighborhood design. TOD benefits the entire community through fundamental elements of design that can be included in existing development regulations and adopted as development policy. Implementation of TOD through revision of existing development policy is an innovative and proactive measure that can be used to overcome the challenges presented by growth and development and improve the quality of life for all citizens of Frederick County.

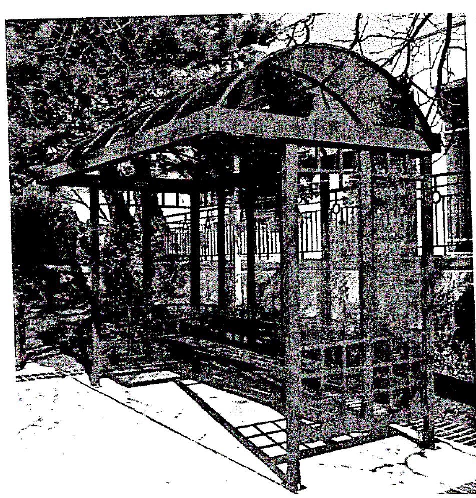
APPENDIX A: TRANSIT ACCESSIBILITY CHECKLIST

1.	Is the proposed development located within the current or planned transit service area?	Yes	No
2.	Is the proposed development expected to generate enough ridership activity to warrant transit service?	Yes	No
3.	Is the development designed so that efficient transit service can be provided (for example, buildings are oriented toward the street with parking areas located to the side and/or rear)?	Yes	No
4.	Is the development located on or accessible to a major roadway?	Yes	No
5.	If the proposed development is located on a major roadway, would a bus turnout be appropriate?	Yes	No
6.	Is a bus pad planned for bus layover points or bus turnout?	Yes	No
7.	Are the intersections, entrance radii, and lane widths adequate to accommodate buses?	Yes	No
8.	Is the street network interconnected, providing direct and convenient pedestrian access through the development?	Yes	No
9.	Are convenient pedestrian paths proposed between buildings and transit stops?	Yes	No
10.	Are the proposed pedestrian paths direct, well lit, wheelchair accessible, and paved?	Yes	No
11.	Are there safe, paved, well-lit, accessible areas for bus stops?	Yes	No
12.	Are the bus stops centrally located to serve as much of the development as possible?	Yes	No
13.	Is the proposed development expected to generate enough ridership activity to warrant a passenger shelter?	Yes	No
14.	Does the proposed passenger shelter meet safety and accessibility standards?	Yes	No
15.	Does the proposed passenger shelter provide passenger amenities?	Yes	No
16.	Have provisions been made to maintain the shelter and the surrounding area?	Yes	No
17.	If the development is in a commercial or industrial area, would a commuter parking lot be appropriate?	Yes	No

APPENDIX B: BUS STOPS

A bus stop is any on-street or off-street location where passengers board and alight a bus. Stops can be located in urban, suburban, and rural locations.

This section includes recommendations for three types of bus stop topics: **Spacing and Placement**, **Design**, and **Customer Features**. Each topic includes background information that explains and defines the topic and qualitative and/or quantitative recommendations. For some topics, implementation information is also provided.



SPACING AND PLACEMENT

Bus stop spacing and placement are important components for a transit agency to consider when creating a new route or modifying an existing route. Spacing should maximize ridership and promote efficient bus movement. Bus stop placement should maximize passenger safety and convenience both on the bus and traveling to and from the stop. Bus stop placement should also consider the safety of other roadway users.

BUS STOP SPACING

The table below lists ranges and typical spacing between bus stops for downtown core, urban, suburban, and rural locations.

Environment	Stops Per Mile	Typical Spacing (feet)
Downtown Core	10 to 12	450
Urban	5 to 10	750[1]
Suburban	4 to 6	1,000[1]
Rural	As needed	As needed

- **Downtown Core—**there should be 10 to 12 stops per mile in the high density commercial and business center (e.g., downtown Baltimore).

- **Urban settings—**there should be 5 to 10 stops per mile with variability given to the presence of individual travel generators (e.g., malls, hospitals, colleges, existing or proposed business, retail, and residential facilities). Abutting topography (e.g., slope, swale, drainage) may impact specific bus stop placement.

- **Suburban settings—**there should be 4 to 6 stops per mile with variability given to the presence of individual travel generators (e.g., malls, hospitals, colleges, existing or proposed business, retail, and residential facilities). Abutting topography (e.g., slope, swale, drainage) may impact specific bus stop placement.

- **Rural settings—**stops should be located at key crossroads and travel generators (e.g., malls, hospitals, colleges, existing or proposed business, retail, and residential facilities). Abutting topography (e.g., slope, swale, drainage) may impact specific bus stop placement.

BUS STOP PLACEMENT

Placement of On-Street Bus Stops

- Bus stops must be placed in locations where people can board and alight safely.

- All new bus stops must comply with ADA requirements.[2]

- Bus stops must be visible to street traffic.

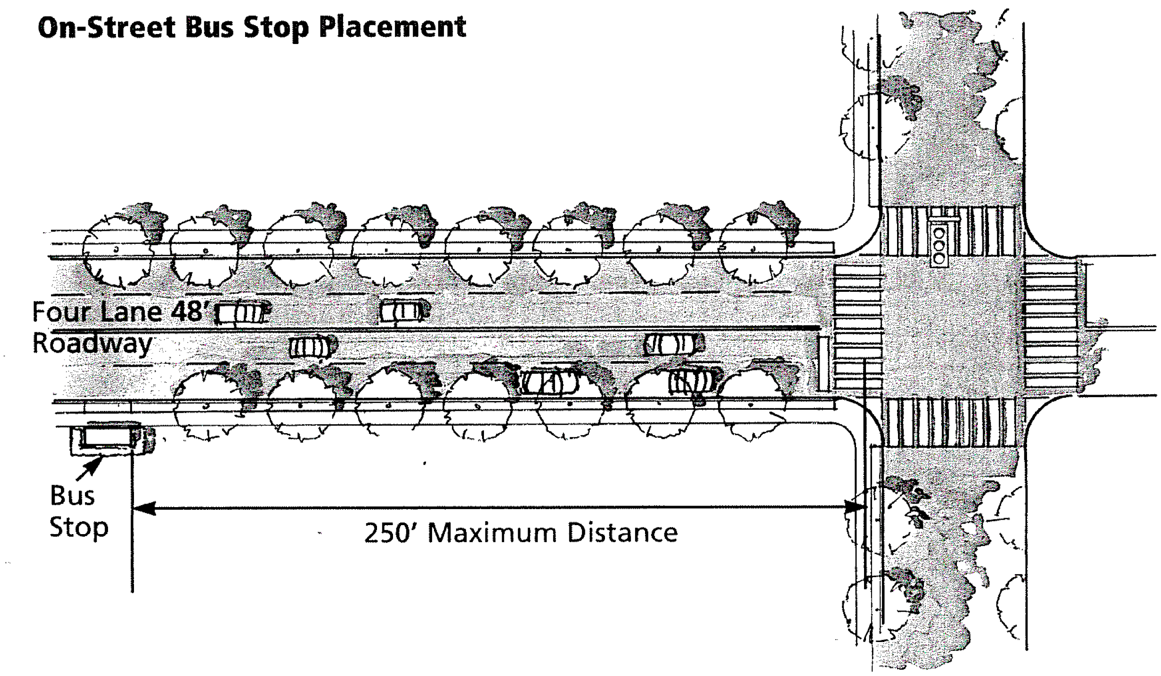
- Unless dictated by the existence of a travel generator, stops should be placed at intersections, preferably signalized intersections, to increase access to service and reduce pedestrians crossing a street at mid-block.

- At major transfer points, stops should be located so that transferring passengers do not need to cross a street to transfer. When there are multiple transfer movements at an intersection, the stop location should reflect the volume movements.

- On roadways greater than 48 feet wide with a posted vehicle speed limit of 35 mph or higher and traffic volumes greater than 400 vehicles per lane in peak hours or 5,000 vehicles per lane per day, bus stops should be located as close to the intersection as possible with a maximum of 250 feet to the signalized pedestrian crossing.

- Bus stop design, access, and location should be reviewed with the SHA District Engineer or the appropriate highway operating agency.

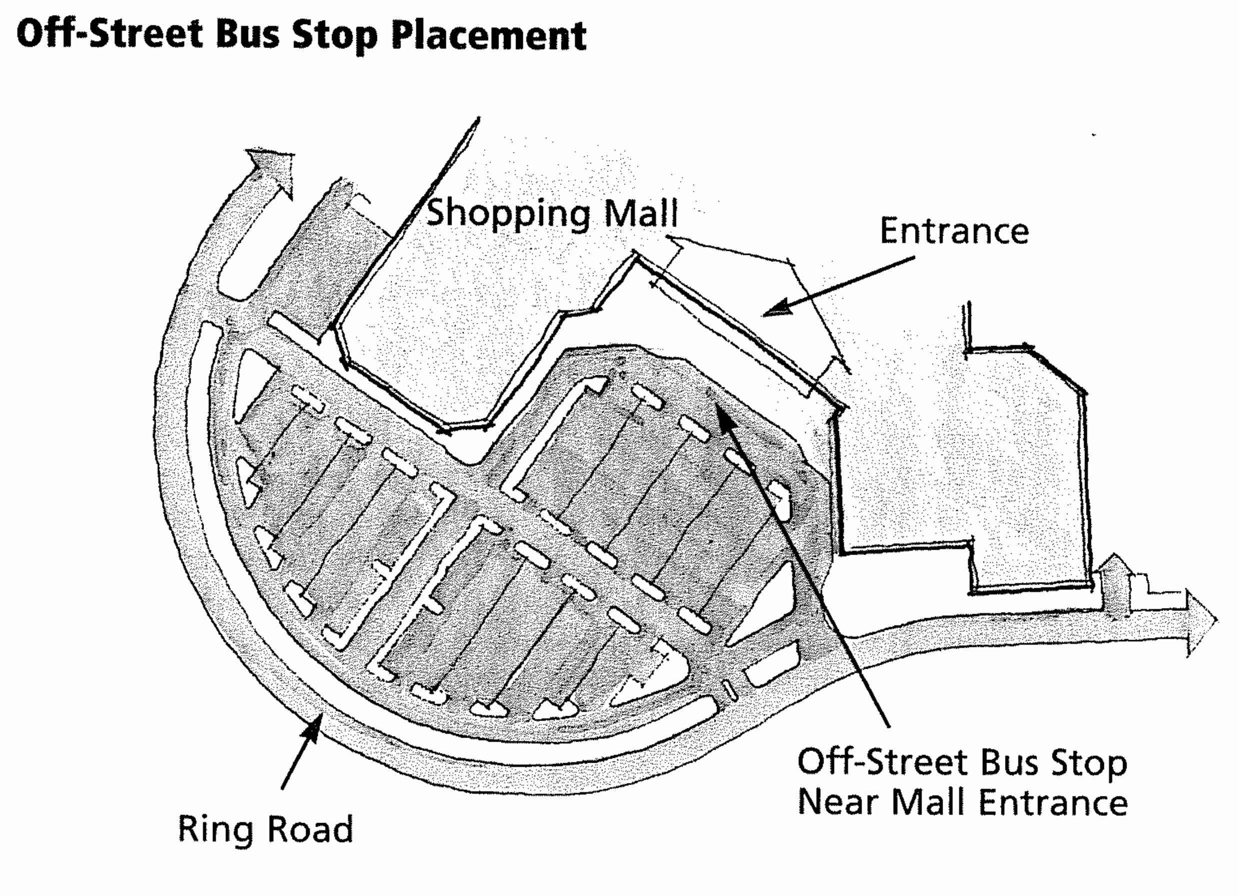
On-Street Bus Stop Placement



Placement of Off-Street Bus Stops

- Off-street stops should be used when large travel generators, such as a hospital or shopping mall, are set back from the roadway and would require walking an excessive distance.

- Off-street stops should be used when the location of the bus stop would cause passengers to cross the roadway at unsafe locations.



FLAG STOPS

Flag stops are used by some transit agencies, typically in suburban and rural areas, where no designated bus stops exist. To board, the patron signals to the driver by waving. Transit agencies emphasize to riders that they should wait at safe, visible locations along the route where there is sufficient room for the bus to completely pull off of the roadway. To alight the bus, the patron asks the driver to stop. Similar to picking up a passenger, the bus driver should find a safe place to completely pull the bus off of the roadway.

- If flag stops are used, they should not be provided on roads with a posted speed limit exceeding 40 mph unless an adequate pull-off area is present.

DESIGN

BUS STOP GEOMETRICS

Bus stop geometric guidelines ensure that buses have adequate room to maneuver toward and away from the bus stop and to decelerate and to accelerate away from the stop based on roadway speed.

Bus stops should not be provided on roads with posted vehicle speed limits exceeding 40 mph unless a pull-off area is present. Right turn lanes and paved shoulders are acceptable pull-off areas.

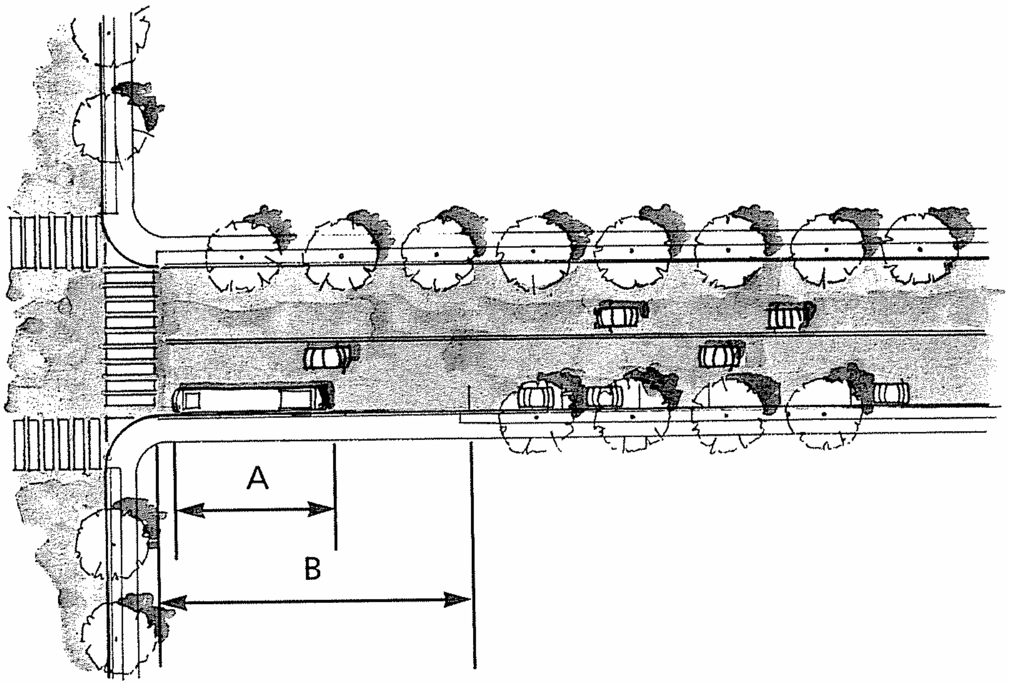
Sketches for bus stop geometrics are provided on pages 21 through 25 for Farside, Nearside, Mid-Block, Pull-Off, and Sawtooth stops. For bus stops with multiple routes, consideration can be given to increasing the total stop length.

Bus Stop Lane Width

- For all new on-street bus stops, the desirable width is the traffic lane or 12 feet, whichever is greater.

- For all new bus stop pull-off areas, the desirable width is 12 feet and the minimum width is 10 feet.

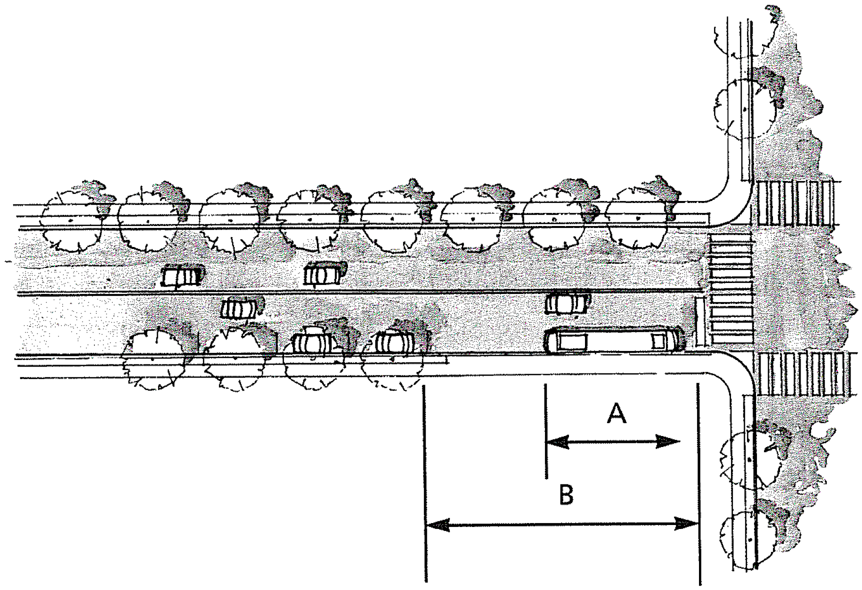
Farside Bus Stop



Bus Stop Length Recommendations

Posted Speed Limit (mph)	**A** **Bus Length** (feet)	**B** **Total Stop Length** (feet)
30 or Less	Less than 30	80
	30 to 45	90
	60	110
Over 30	Less than 30	120
	30 to 45	130
	60	150

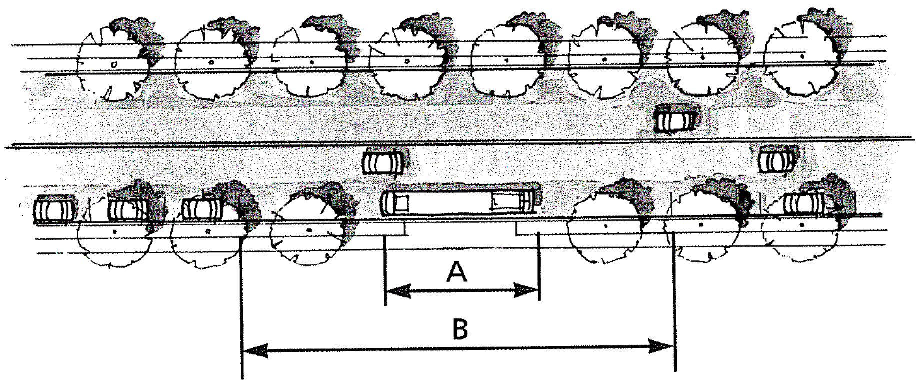
Nearside Bus Stop



Bus Stop Length Recommendations

Posted Speed Limit (mph)	**A** **Bus Length** (feet)	**B** **Total Stop Length** (feet)
30 or Less	Less than 30	100
	30 to 45	110
	60	130
Over 30	Less than 30	120
	30 to 45	130
	60	150

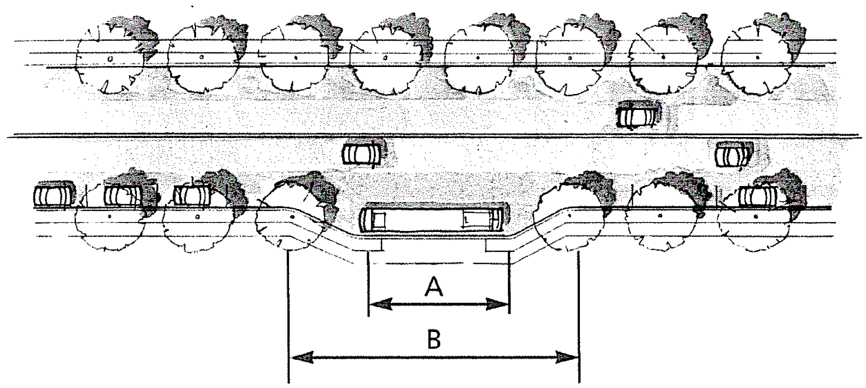
Mid-Block Bus Stop



Bus Stop Length Recommendations

Posted Speed Limit (mph)	**A Bus Length** (feet)	**B Total Stop Length** (feet)
30 or Less	Less than 30	140
	30 to 45	150
	60	170
Over 30	Less than 30	240
	30 to 45	250
	60	270

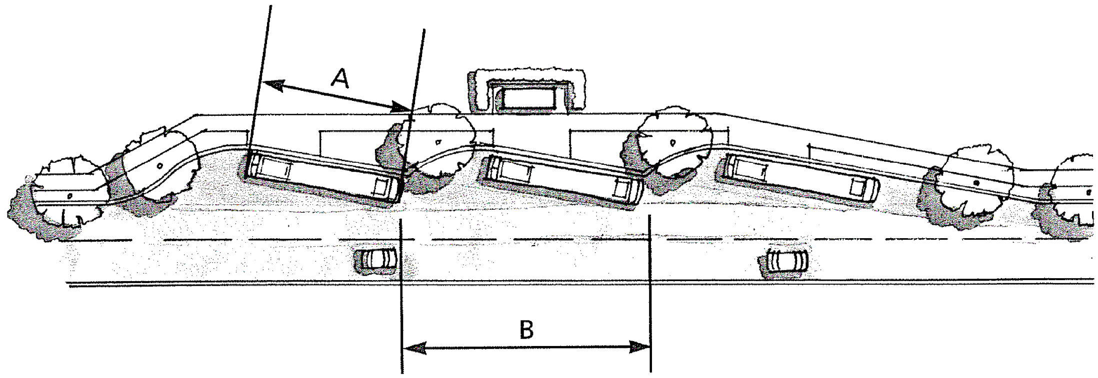
Pull-Off Bus Stop



Bus Stop Length Recommendations

Posted Speed Limit (mph)	**A** **Bus Length** (feet)	**B** **Total Stop Length** (feet) [entrance taper + curb stop area + exit taper]
30 or Less	Less than 30	140 [50 + 40 + 50]
	30 to 45	150 [50 + 50 + 50]
	60	170 [50 + 70+ 50]
Over 30	Less than 30	240 [100 + 40 + 100]
	30 to 45	250 [100 + 50 + 100]
	60	270 [100 + 70 + 100]

Sawtooth Bus Stop



Bus Stop Length Recommendations

Posted Speed Limit (mph)	**A** **Bus Length** (feet)	**B** **Total Stop Length** (feet) [curb stop area + exit taper]
30 or Less	Less than 30	55 [40 + 5 + 10]
	30 to 45	65 [40 + 15 + 10]
	60	85 [40 + 35 + 10]
Over 30	Less than 30	55 [40 + 5 + 10]
	30 to 45	65 [40 + 15 + 10]
	60	85 [40 + 35 + 10]

<u>Bus Bulbs</u>

Bus bulbs (also referred to as curb extensions, bulb outs, or nubs) are used to enhance the waiting area at bus stops. A bus bulb is a section of sidewalk that extends from the curb of a parking lane to the edge of the through lane. When used as a bus stop, the buses stop in the traffic lane instead of weaving into the bus stop that is located in the parking lane—therefore, they operate similarly to curb-side bus stops. Bus bulbs offer additional area for patrons to walk and wait for a bus and provide space for the patron amenities such as shelters and benches.

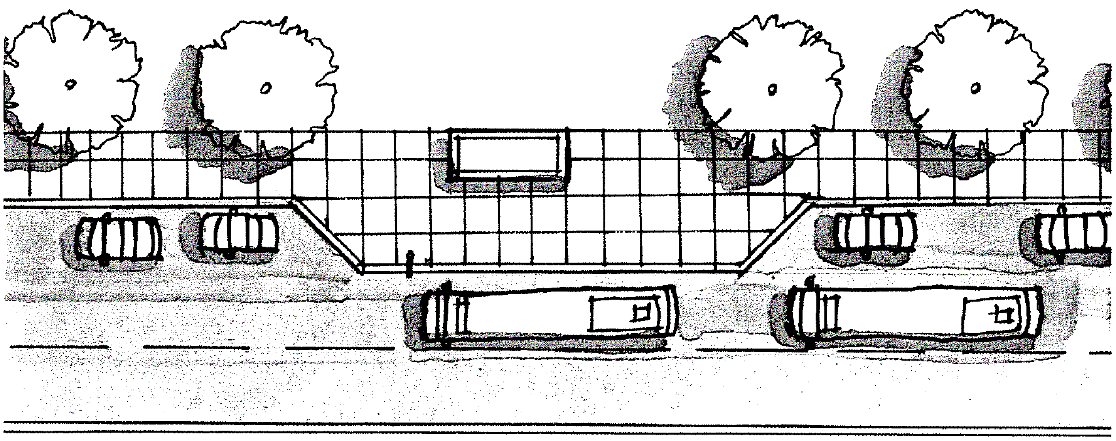
Bus bulbs have also been used as a traffic-calming technique. Bus bulbs reduce pedestrian crossing distances, create additional parking (compared with typical bus zones), and mitigate traffic conflicts between autos and buses merging back into the traffic stream. Bus bulbs should be designed to allow for an adequate turning radius for right-turn vehicles.

Bus bulbs should be considered at sites with the following characteristics:

- High pedestrian activity,

- Crowded sidewalks,
- Difficult pedestrian street crossings, and
- Bus stops in travel lanes.

Plan View of Bus Bulb



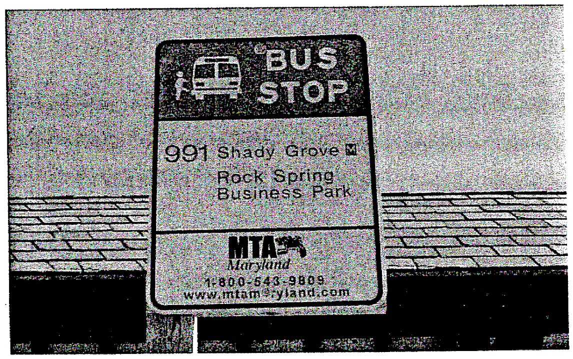
SIGNAGE

Bus stop signs serve many purposes. They mark stop locations and promote awareness of the transit system to the general public. Signage with detailed system information, such as route numbers, route destinations, and transit agency contact information, are valuable marketing and public awareness tools, but must be maintained to ensure the accuracy and validity of information.

Bus stop signs should be provided at all bus stops. Signs should be positioned at a safe location that is visible to street traffic. The following physical characteristics are recommended:

- Bus stop signs should measure 18 inches wide by 24 inches high.
- Bus stop signs should only display transit information.
- Parking regulations for the stop area should be on a separate sign. The restrictions should be consistent with local regulatory ordinances on parking. The parking regulation sign should be located so as to clearly communicate the location where parking is restricted.
- Appropriate color contrast, light lettering on dark background or dark lettering on light background, should be used.
- Individual transit agencies may choose any color scheme as long as the color contrast criterion is met.
- To comply with ADA requirements, bus stop signs must be at least 80 inches from the bottom of the sign to the sidewalk.

- If the roadway has curb and gutter, the pole supporting the sign should be at least 2 feet from the inner face of the curb.[3] If no curb is present, the pole supporting the sign should be more than 2 feet from the edge of the shoulder, or at least 6 feet from the edge of the travel lane.



The guidelines recommend that signs convey three types of information:

- Top Section –Defines that this is a bus stop.
- Middle Section—Lists bus route information.
- Bottom Section—Includes transit agency contact information.

Recommended Bus Stop Sign Layout

TOP: The words “BUS STOP” should be placed on the right side of the sign. The international bus stop symbol of a passenger boarding a bus should be located on the left side of the sign. The symbol and/or “Bus Stop” should be a minimum of 3 inches in height.

MIDDLE: This section shows the route identifier for the bus stop (e.g., letter, number, name, color, etc.) and is unique for each stop. The route identifier should be at least 3 inches tall where practical. If there is space, the route destination should follow the route identifiers. If the bus route provides service to a rail station or an airport, the station or airport name and logo should be listed if there is space. If multiple agencies serve the same bus stop, the transit agency logo or name precedes each route identifier so that it is clear which transit agency corresponds to which route.

Where practical, the text height for route information should be 3 inches. This is consistent with ADA guidelines that recommend a 3-inch letter height size on bus stop signs.[4] When it is not feasible to show all route information at the 3-inch letter height, the following guidelines should be used:

- In situations where there is only one agency providing service with only one route, the letter height for the route identifier should be 3 inches. The route destination should be displayed at 3 inches or as tall as possible to fit within the width of the sign either to the right of the route identifier or in a second row below. Multiple destinations for a single route can be written on one line and separated with a slash (/) or written on separate lines. If the route connects to another transportation mode, that mode’s logo should be shown to the right of the route destination.

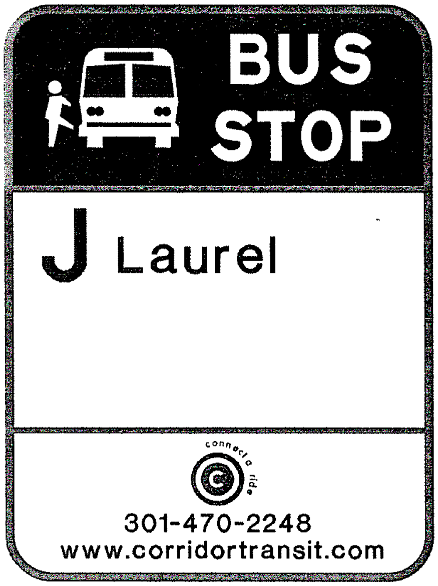
- For all other sign scenarios, multi-agency and/or multi-route, all information pertinent to a given bus route should be displayed as large as possible on a single line. Each bus route should be displayed on an individual row.

BOTTOM: The bottom part of the bus stop sign should display the transit agency’s logo. In the absence of an agency logo, the transit agency should use its name. Below the agency logo and/or name is the transit agency’s general system information telephone number. Below the phone number is the agency’s Web address. Similar to the phone number, the Web site should be a source for rider and trip planning information. If multiple transit agencies serve a particular stop, then the bottom section is split into equal areas and each of the transit agencies’ contact information is displayed within the smaller boxes.

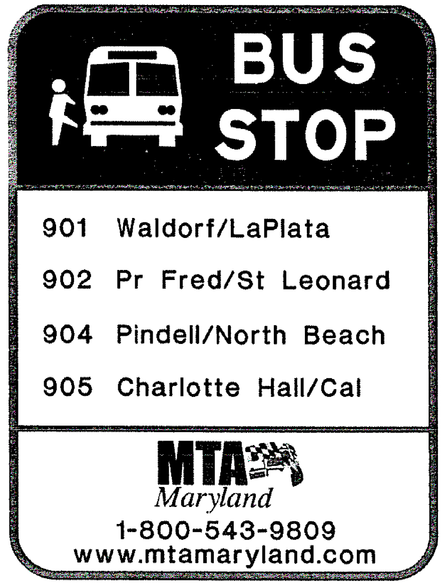
REVERSE SIDE: The reverse side of the bus stop sign should display the words “BUS STOP”.

The following bus stop sign examples are for single agency/single route, single agency/multi-route, and multi-agency/multi-route.

**Single Agency/
Single Route Sign**



**Single Agency/
Multi-Route Sign**



**Multi-Agency/
Multi-Route Sign**

ROADWAY PAVEMENTS

The areas where buses brake, accelerate, and turn should require special attention.[5] Unreinforced pavements, such as asphalt, deform with the weight and frequency of buses coming and going at the stop. During the summer months, the deterioration process accelerates when hot temperatures and sunlight soften the black asphalt. This deterioration of the pavement could lead to increased vehicle maintenance costs and customer complaints as a result of the rough, bumpy pavement. To address these issues, transit agencies should build pads at bus stops following the guidelines below:

- Locations where vehicles brake, accelerate, and turn should be paved with materials of sufficient strength to accommodate repetitive loads of a bus.
- The pad should be the width of the curbside lane for bus stops.
- The sizes of the pads vary from one agency to another based on the type of bus stop: curbside, open bus bay, queue jumper bus bay, or nubs. The concrete pad should be a minimum of 11 feet wide (preferably 12 feet) for bus bays.
- The pad length should accommodate the maximum number of buses stopping simultaneously and provide adequate distance for entrance and exit tapers.
- If a bus stop is located within private property that is not owned by the transit agency, then the transit agency should present options to the owner and discuss responsibility for installation and maintenance.

The table below lists recommendations for roadway pavements at urban, suburban, and rural bus stop locations.

Bus Stop Environment	Recommendations
Urban	Reinforced concrete pads at urban bus stops
Suburban	Asphalt or reinforced concrete for suburban locations based on volume, service frequency, and stop type. Pads at transfer centers and multi-route locations should receive high priority.
Rural	Asphalt may be used unless high volume or stop significance warrants the installation of a concrete pad.

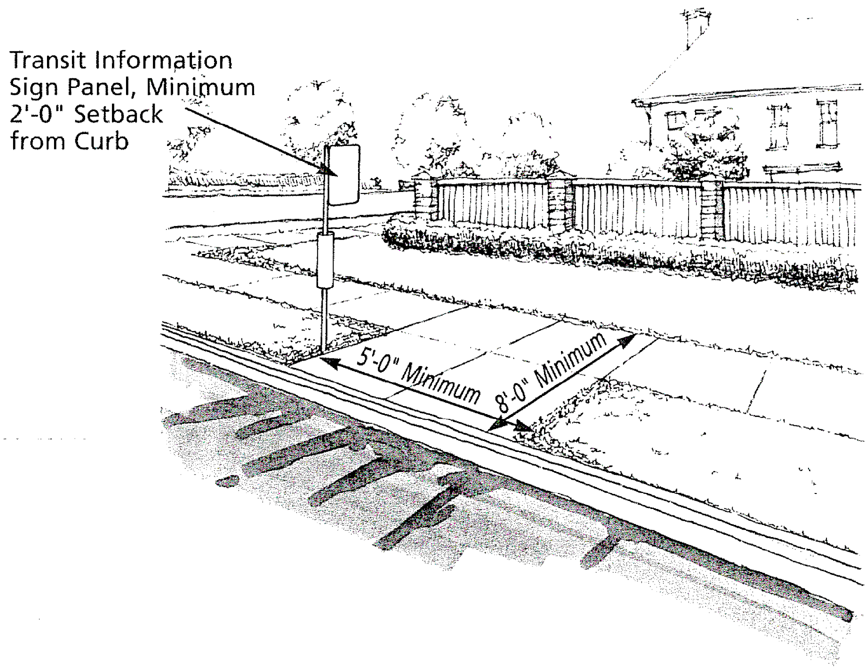
PEDESTRIAN SURFACES

Pedestrian surfaces are any hardened surface on which a patron boards or alights a bus. Transit riders should not wait for buses in the roadway or on unpaved surfaces. Pedestrian surfaces increase passenger safety by providing passengers with a durable, slip-free surface located away from the roadway. Pedestrian surfaces can also be designed to enhance the visual appearance of the stop by using artistic floor patterns or pavers.

The pedestrian surface must comply with ADA requirements and should:

- Be 5 feet wide by 8 feet deep.
- Consist of a hardened material such as concrete, asphalt, or pavers.
- Provide adequate visibility to approaching buses.
- Connect to adjacent sidewalks or another hardened surface to provide pedestrian accessibility to and from the bus stop location.

Bus Stop Waiting Area



LIGHTING

Bus stops that are well lit provide patrons with an enhanced perceived sense of security and safety. Bus stop lighting also increases a bus driver's ability to see patrons waiting at a stop. At poorly lit stops, bus drivers may pass by bus stops with people waiting to board.

Illumination requirements currently vary among public transportation agencies. The generally accepted minimum threshold for sufficient lighting at bus stops ranges from 2 to 5 foot-candles.[6] The two primary cost considerations for lighting include initial installation cost and availability of power. The most cost-effective solution to provide lighting at a transit stop is to locate bus stops near existing street lamps. This practice is very common for transit service within urbanized areas.

Recent research has investigated the use of solar-powered transit stop lighting.[7] The primary benefit of using this type of power source is that it is self-generating. The battery used to operate the light at night is charged during the day by solar energy. This type of technology eliminates the need to be near an electric power supply.

Bus stop lighting is desirable and transit agencies are encouraged to work with the appropriate public agency to install lighting. Key recommendations relative to lighting are:

- Bus stops should be placed near existing lighting sources whenever possible. In most surroundings (urban, suburban, and rural), the need for a transit stop is within close proximity to a developed area where some lighting exists. In urban environs, this is especially true, since most street corner lampposts provide sufficient light for the corner and most of the mid-block area.

- It is recommended that vandal-resistant fixtures be used. Lampposts should not have exposed bulbs or elements.

- Lighting equipment should be easily accessible for repair and maintenance.

- Solar-powered transit stop lighting should be investigated and used when appropriate.

LANDSCAPING

Landscaping improves the area around a bus stop and can provide shade in the summer. Effective streetscape plans improve the appearance of a street and can make the area more pedestrian-friendly.

Bus stop landscaping is desirable. If transit agencies allocate funding towards trees and landscaping, the following guidelines are suggested:

- Shade trees should optimize shading protection for the waiting customer at the bus stop.

- Avoid planting shallow-rooted trees that will damage sidewalks and concrete surfaces.

- Shrubbery should be planted at the discretion of the local jurisdiction.

- Shrubbery should be kept low to ensure visibility between the transit patron and transit operator.

- Encourage local jurisdictions or those responsible for right-of-way maintenance to groom and maintain trees, shrubbery, and grass.

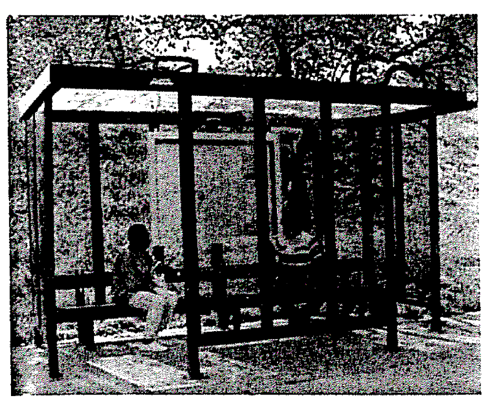
CUSTOMER FEATURES

SHELTERS

A bus stop shelter serves as a visual marker for the bus stop and offers protection from wind, rain, and snow to waiting passengers. It also can provide visual and aesthetic interest. A minimum of 25 daily boarding passengers is recommended to warrant the installation of a bus stop shelter.

For all transit systems, the following installation guidelines should be used:

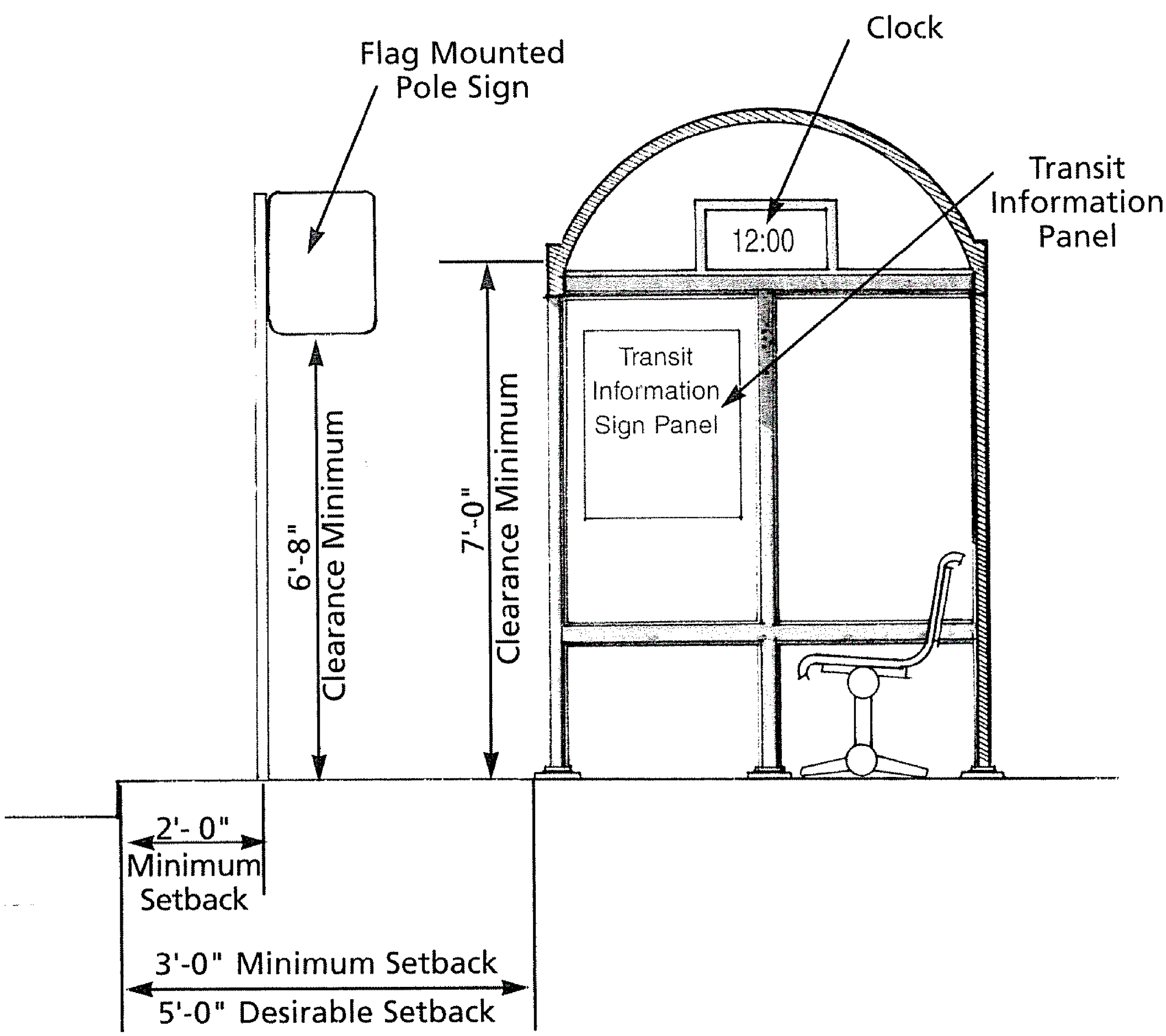
- The minimum design specifications are 3 walls (a rear and two sides) with a minimum covered area (under roof) of 48 square feet. For shelters with four walls, the front side must have two entrances. For areas with space limitations, other shelter types, such as umbrella or half-wall can be used.
- All shelters should have interior seating.
- All shelters should include a display case for transit information.
- Shelters should have a minimum front clearance of 3 feet (5 feet is desirable) from the shelter to the edge of the curb.[8]
- All new shelters should comply with ADA guidelines.
- The shelter should be placed near the front of the bus stop and be visible to vehicle and pedestrian traffic.[8] The shelter should not be placed without giving due consideration as to how it might affect intersection operations, particularly sight distances for motorists and pedestrians.
- The shelter should be visually compatible with adjacent structures.
- The shelter side panel at the end where the bus approaches should be free from any obstruction (e.g., transit information panel or advertisement) that would block the view of an approaching bus.
- Clocks are a desirable feature, but installation is left to the discretion of individual transit agencies.



For the maintenance and repair of bus stop shelters, the following guidelines are suggested:

- Shelter surfaces should be cleaned at least once every 6 months.
- Graffiti should be removed and any vandalized or broken equipment should be repaired as soon as possible.
- Shelter materials that minimize maintenance and vandalism should be used.
- Transit agencies are encouraged to establish "Adopt-a-Shelter" programs that encourage local businesses and organizations to maintain the shelter. Recognition should be given to the party adopting the shelter.

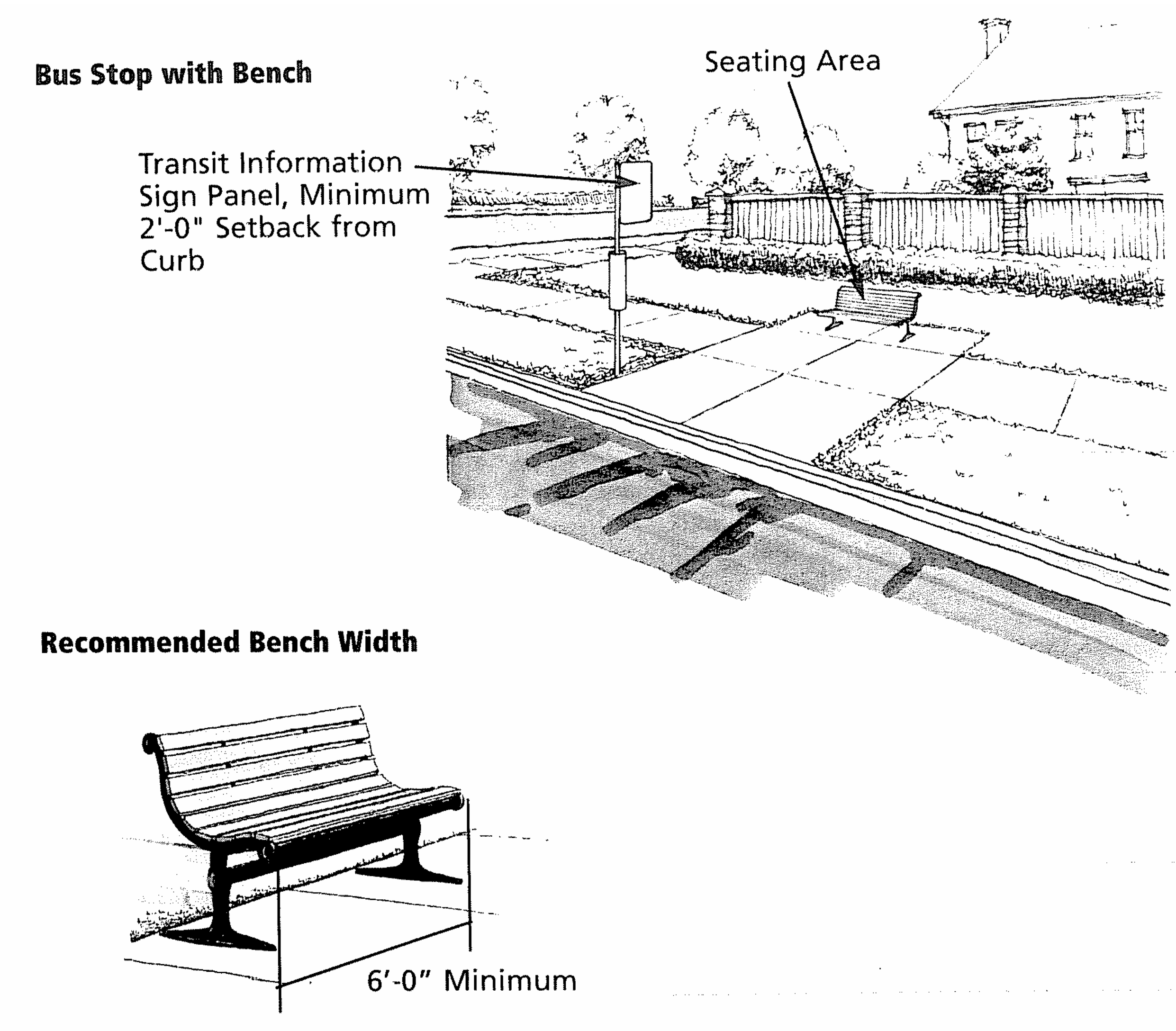
Bus Stop Cross Section



SEATING

Bus stop seating increases patron comfort and reduces perceived waiting time.

- Stops with daily boards of at least 10 passengers warrant the installation of a bench.
- The minimum bench size should be 6 feet in width.
- The bench should be mounted and secured on a concrete surface.[9] The size of the surface may vary with each location, but should be consistent with ADA requirements.
- A minimum front clearance of 4 feet is recommended between the street curb and the edge of seat.[10]
- Seats or benches should be visible to traffic and be near the front of the bus stop.
- Transit agencies should use materials that minimize maintenance and vandalism.



INFORMATION BOXES

Transit information at a bus stop helps passengers to use transit services. Information boxes are units that display transit schedules, maps, and other information. The box is typically mounted on a post or pole and can be multi-sided. Similar to an information box, a transit information panel contains transit timetables and maps. Information panels are usually mounted on bus stop shelter walls. It is critical that information provided be up to date.

- For bus stops that have more than 10 boardings and do not have a shelter, it is recommended that an information box be mounted on the sign pole below the bus stop sign.

- At a minimum, the transit information provided should include a route map for the route(s) serving the bus stop, a schedule/timetable for the route(s) serving the bus stop, and fare information.

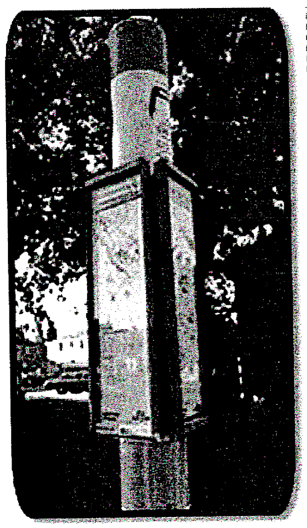
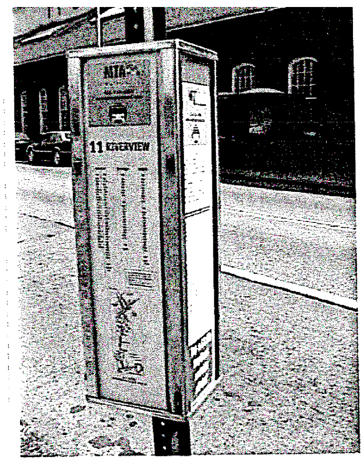


Photo courtesy of
Daytech Manufacturing, Inc.
www.daytechmfg.com



TRASH RECEPTACLES

Trash receptacles promote a litter-free environment at bus stops.

The recommendations for trash receptacles at bus stops include:

- Transit agencies will determine applicability on a case-by-case basis.

- The trash receptacle should be secured to the ground.

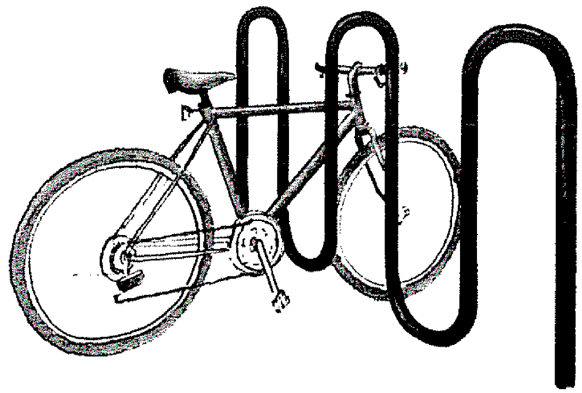
- Trash should be removed at least once a week.

- Transit organizations are encouraged to work with local jurisdictions, community groups, and neighborhood organizations to establish trash removal responsibilities. “Adopt-a-Stop” programs are written agreements with civic groups, businesses, or community organizations to help maintain the cleanliness of the bus stop.

BICYCLE STORAGE

- The guidelines recommend that transit agencies should install bicycle racks whenever a bus stop is near a bike trail and at locations where bicycle use by transit passengers is expected.

U-Channel Bicycle Rack

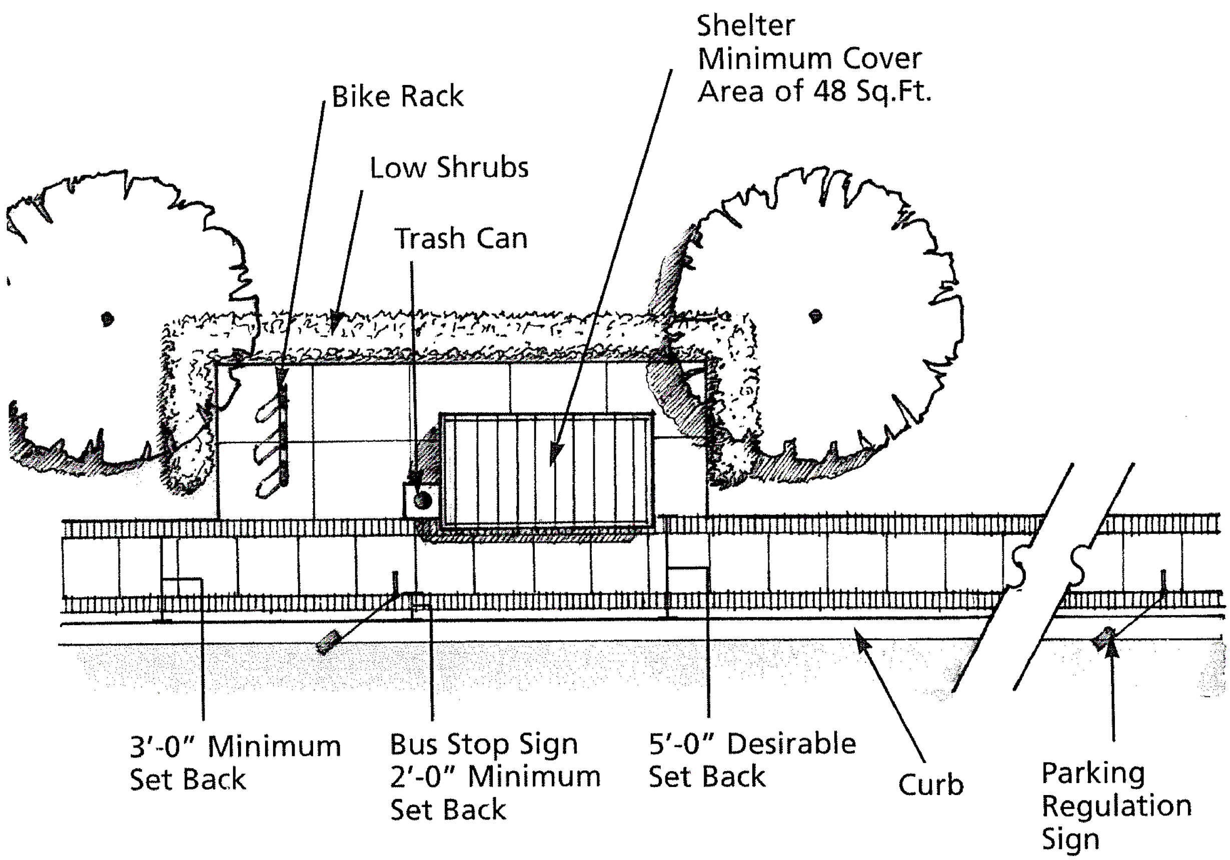


TELEPHONES

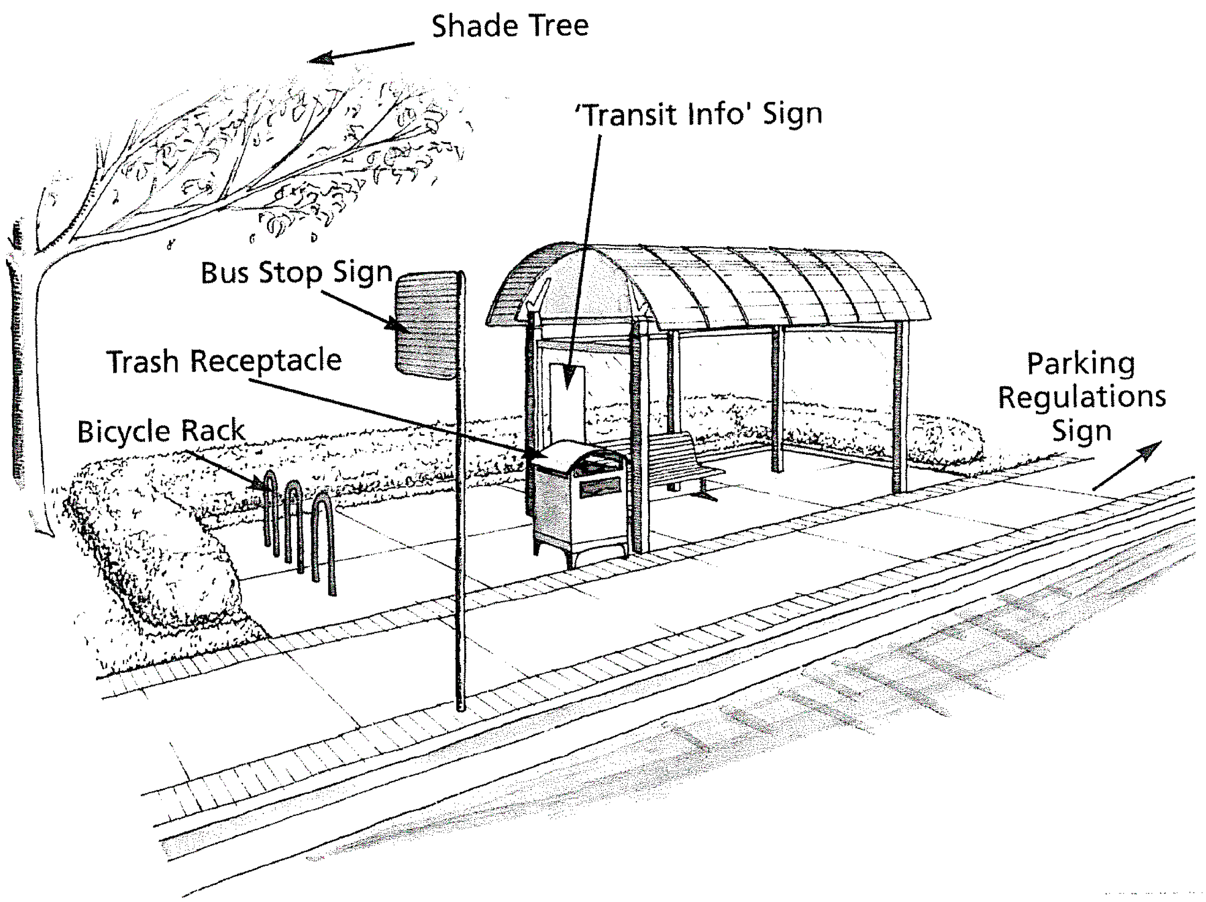
Telephones allow passengers to make travel arrangements such as being picked up from a stop by a taxicab or automobile. Telephones are also a valuable communication device during emergencies.

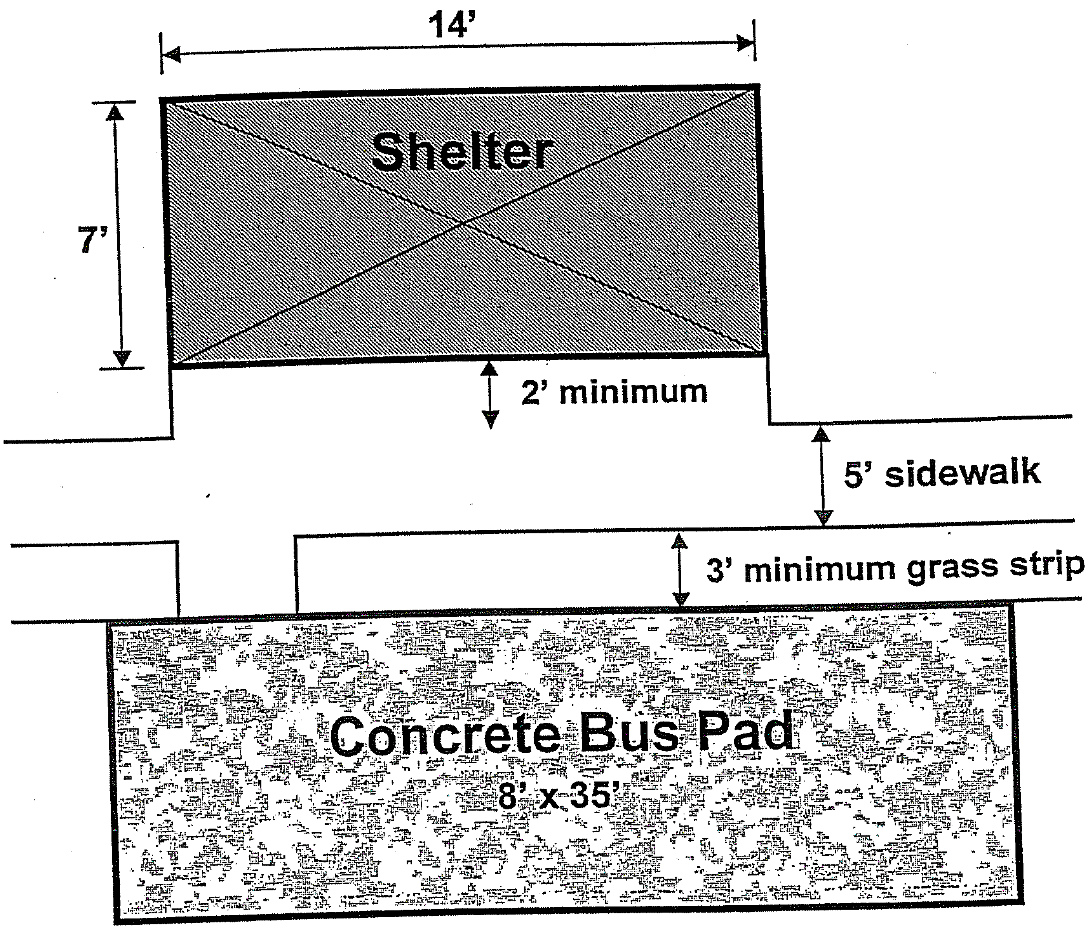
- Transit agencies should encourage telephone companies to install and maintain telephones at major bus stops.

Plan View of Bus Stop Layout



Recommended Bus Stop Layout





Typical Bus Shelter Layout

(Not to scale)

Transit Services of Frederick County

APPENDIX C: VEHICLE MANEUVERABILITY

Technical Specifications

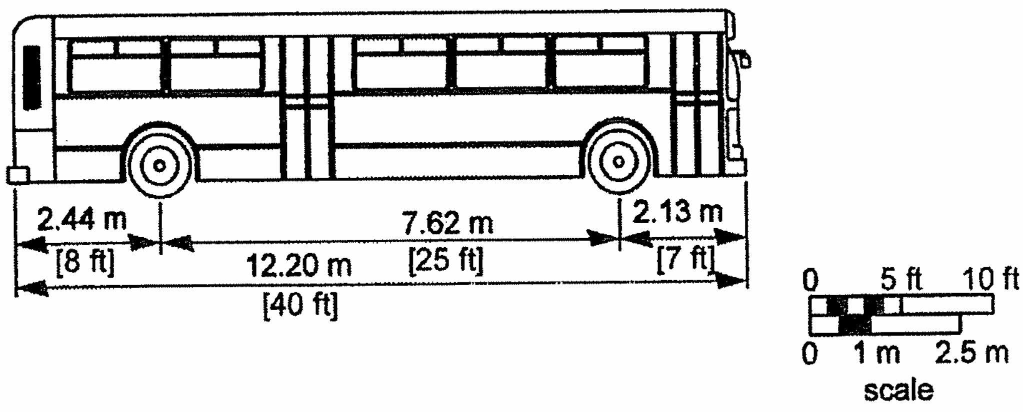
Most modern arterial streets and highways are designed to accommodate buses, trucks, and other large vehicles, and bus drivers have little problem maneuvering on such roadways. However, in office parks, shopping centers, and residential neighborhoods roadway designs are more restrictive. Road sections are narrow in order to make pedestrian crossings easier or to encourage drivers to reduce speeds. This environment can make it difficult for a bus driver to keep the bus in lane, or to avoid hitting or mounting the curb when making a right turn. Streets that are expected to carry bus traffic and facilities designed for bus operation, such as terminals, must be designed appropriately.

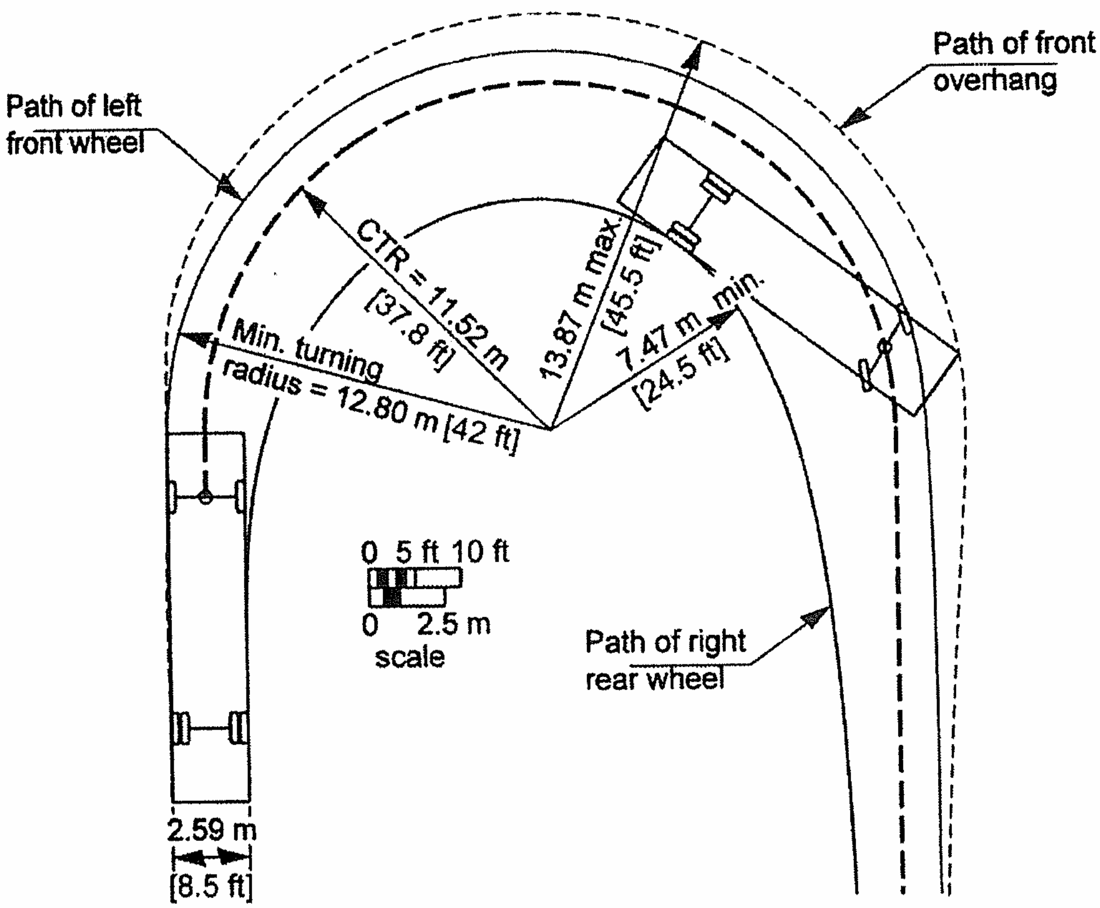
Each bus model has different characteristics and has a different turning envelope. When streets or facilities are designed it is not known what exact type of bus will be operating there, so the design bus envelope is established to cover almost all of the vehicles in general service. Turning templates that establish needed clearances are available from many sources. Most of the templates are based on a standard 40-foot long (bumper-to-bumper) transit bus. However, many over-the-road coaches now being produced are 45 feet long. While most of these vehicles can be safely operated within the standard envelope, the specifications provided by the manufacturer should be used when new facilities are designed. Articulated buses are designed to maneuver within the turning envelope of a standard bus.

The figure on the following page illustrates the turning template for a 40-foot bus. The controlling elements for a right turn are the left front bumper, which swings the widest arc, and the right rear wheel, which has the shortest turning radius.

Standard templates for roadway design to accommodate various types of buses are available from several sources and are listed in the selected bibliography on page 46.

40 Foot Bus Turning Template





- Assumed steering angle is 41°
- CTR = Centerline turning radius at front axle

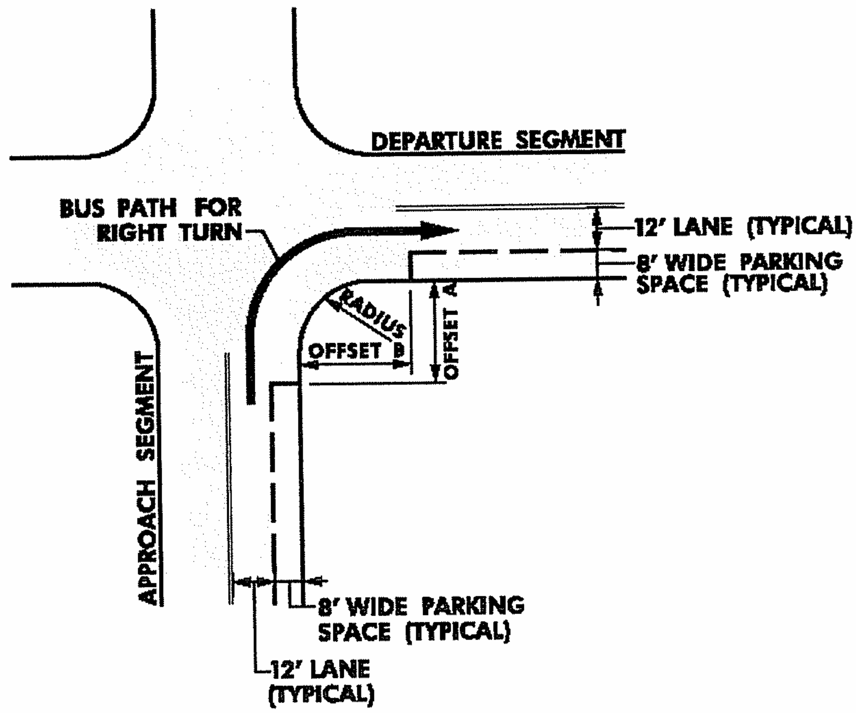
APPENDIX D: INTERSECTION DESIGN

The layout and design of an intersection can significantly affect the ease of transit operations. Intersection design must consider the following elements and how they relate to transit vehicle turning movements:

- Number and width of travel lanes on approach and departure segments.
- The presence of on-street parking on approach and departure segments.
- The offset of the on-street parking on approach and departure segments.

The figure on the next page illustrates the approximate dimensions needed to accommodate a 40-foot-long bus making a right turn. A standard transit bus can navigate a turn with 12-foot lanes without mounting the curb or encroaching on adjacent travel lanes if a 40-foot radius is provided. If there is a parking lane on both approaches or on the departure segment, then the bus will be able to make the turning movement with a smaller radius and without encroaching on adjacent lanes (see Cases 3 and 4 in the table on the next page).

Right Turn Movement for a 40-foot Bus at an Intersection



Intersection Layout	Approximate Dimensions		
	RADIUS	Offset A	Offset B
Case 1: No On-Street Parking	40'	N/A	N/A
Case 2: On-Street Parking Before Turn	40'	35'	N/A
Case 3: On-Street Parking After Turn	35'	N/A	50'
Case 4: On-Street Parking Before and After Turn	30'	40'	55'

There are a number of situations where the roadway conditions may not allow or warrant the radii listed in the table. For example, if there is a local roadway with low traffic volumes, then a smaller radius that facilitates pedestrian movements could be provided. However, if a smaller radius is provided or there is an existing radius that is smaller than those listed in the table, then the bus may encroach on the opposing travel lanes on the departure segment. If there are additional lanes in the same direction on the departure segment, then the radius can be reduced and the bus will simply turn into two lanes.

SELECTED BIBLIOGRAPHY

Creating Transit-Supportive Land-Use Regulation, Edited by Marya Morris, American Planning Association, Planning Advisory Service Report #468, 1996.

Encouraging Public Transportation Through Effective Land Use Actions, USDOT May 1987.

Maryland Transit Guidelines, Maryland Mass Transit Administration, May 2002.

Developing Choices for the Future - The What, Why and How of Transit-Oriented Development, Regional Transportation Authority of Northeastern Illinois, June 1995.

Transportation & Land Use Innovations - When You Can't Pave Your Way Out of Congestion, Reid Ewing, American Planning Association, 1997.

Planning, Developing, and Implementing Community-Sensitive Transit, Federal Transit Administration, May 1996.

Planning & Design for Transit*,* Portland Tri-Met, March 1993.

1990 Nationwide Personal Transportation Survey

REFERENCES

1 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 18.

2 Americans with Disabilities Act: Accessibility Guidelines for Buildings and Facilities, Transportation Facilities, and Transportation Vehicles. U.S. Architectural and Transportation Barriers Compliance Board, Washington, DC, 1994, section 4.30.

3 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 48.

4 Americans with Disabilities Act: Accessibility Guidelines for Buildings and Facilities, Transportation Facilities, and Transportation Vehicles. U.S. Architectural and Transportation Barriers Compliance Board, Washington, DC, 1994, section 4.30.

5 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 43.

6 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 84.

7 TCRP Project A-15 – Part 4, Chapter 2. Transportation Research Board, Federal Transit Administration, pp. 4-5.

8 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 67.

9 TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. Transportation Research Board, Federal Transit Administration, 1996, p. 74.

10 Central Florida Mobility Design Manual (2000), LYNX, The Central Florida Regional Transportation Authority, p. 6.7.